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# Neutron and Gamma (Density) Logging in Welded Tuff

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FOR INFORMATION ONLY

# 'UCCA MOUNTAIN PROJECT
## Technical Implementation Plan

| | |
|---|---|
| No.: | TIP-NF-31 |
| Revision: | 1 |
| Change Notice: | CN TIP-NF-31-1-1 |
| Page: | 1 of 5 |

**Subject:**
NEUTRON AND GAMMA (DENSITY) LOGGING IN WELDED TUFF

**AUTHOR:**
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**Training Required:** Yes ■ No ☐
**Comments:** Training required for personnel involved in Hydrological Property Measurements for Large Block Test

### REVISION HISTORY

| Rev. No. | CN No. | Effective Date | Description of Revision/CN |
|---|---|---|---|
| 0 | | 5/26/94 | Initial issue. |
| 1 | | 7/12/94 | Changes to text, change in section numbering. |
| 1 | CN TIP-NF-31-1-1 | 9/12/97 | Text changes made to responsibilities; addition of 503 DR Hydroprobe Moisture Depth Gauge Operating Manual as addendum. Affects Title Page and pages 2 and 3 of 5. |

APPROVALS:

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## 1.0 PURPOSE

This Technical Implementation Procedure (TIP) describes the field operation, and the management of data records pertaining to neutron logging and density logging in welded tuff. This procedure applies to all borehole surveys performed in support of Engineered Barrier System Field Tests (EBSFT), including the Large Block Tests (LBT) and Initial Engineered Barrier System Field Tests (IEBSFT) - WBS 1.2.3.12.4. The purpose of this TIP is to provide guidelines so that other equally trained and qualified personnel can understand how the work is performed or how to repeat the work if needed. The work will be documented by the use of Scientific Notebooks (SNs) as discussed in 033-YMP-QP 3.4. The TIP will provide a set of guidelines which the scientists will take into account in conducting the measurements. The use of this TIP does not imply that this is repetitive work that does not require professional judgment.

## 2.0 SCOPE

This TIP applies to all density logging and neutron logging for water content performed in support of EBSFT - WBS 1.2.3.12.4.

## 3.0 RESPONSIBILITIES

The Task Leader for EBSFT - WBS 1.2.3.12.4 is responsible for assuring that this procedure is used. The Task Leader is also responsible for assuring that any changes to this procedure are reviewed and incorporated in the next revision.

## 4.0 DESCRIPTION OF PARTS/ASSEMBLAGE AND CHECKOUT

The operations manual (Campbell Pacific Nuclear Corporation, 1984) for the logging tools describes all the components of the logging system used. It also describes the appropriate assemblage and checkout procedures. A copy of the operations manual will be attached to the "Field Copy" of this procedure.

## 5.0 FIELD MEASUREMENTS

The field measurement sequence includes measurements of a standard outside the boreholes and measurements within boreholes for moisture or density testing.

a) Measurement of Standard Counts: The calibration of the moisture or density system is made in terms of a ratio to standard count made with the probe secured within the shielded surface unit or a special calibration fixture. A log will be kept of the standard counts taken before and after each borehole survey, **or suite of surveys (i.e., at the beginning and end of each day's surveys)**, to allow the user to determine when a defect occurs and the rate of change per unit time of course. Selection of an appropriate base station location is discussed in the manual of operation.

b) Borehole Logging: Instructions on how to operate the tools are described in the operations manuals. Additional operational requirements are as follows.

1) Counting time: The counting time at each sampling location should be at least 16 seconds for the neutron measurements and at least 240 sec (4 min.) for the density measurements with the probe remaining immobile during counting.

2) Sampling Interval: The maximum sampling interval (i.e., the distance between individual sampling locations) should be smaller than the radius of investigation of the probe. The radius of the investigation of the neutron probe is a function of the water content of the rock and can be estimated using the formula supplied by the manufacturer in the operations manual. The sampling interval used will be selected such that there is an overlap in the volume of investigation of approximately 20% between consecutive sampling stations. There is no known formula to calculate the radius of investigation of the density probe. The present judgment is that it will be of the same order as that of the neutron probe.

   The range of depths to be sampled in each borehole will be determined based on the results of geohydrologic scoping calculations. The range of depths to be sampled should completely include those sections of the rock mass which according to the scoping calculations will undergo detectable changes in moisture content during the experiment. At present, there is no information available regarding what is the smallest change in moisture content which can be detected with this logging system. The judgment is that a change in moisture content of a few percent of the original value may be detectable. Thus, it is recommended that the section of the borehole to be logged include (as a minimum) those sections where changes in moisture content of 3-4% (relative to the pristine value) are expected.

## 6.0 RECORDS

The data collected during neutron and density surveys will be recorded manually in SNs. The records will identify the borehole, date and time, and persons conducting the survey data. The survey data will include the standard counts obtained before the logging run. **If a number of borehole surveys are performed in one day, record the standard counts at the beginning and end of each day's surveys.** The depths at which each measurement was made, neutron counts (or density), and a standard count obtained at the end of each logging run will also be recorded. The SNs will also list the times and date when the rechargeable battery pack of the unit is recharged and of any maintenance performed on the tool. SNs will be handled in accordance with procedure 033-YMP-QP 3.4.

Documentation of the methods or procedures used to perform the test/activity will be provided in the SNs and the method or approach used will be determined by the Principal Investigator or the person assigned by the Principal Investigator to do the work. As such, deviations from the suggested or typical approaches outlined in this procedure are allowed based on the technical judgment of the scientist responsible for this activity. Revised procedures will then be prepared to reflect changes, when appropriate.

COMPANY

# 503 DR HYDROPROBE®
# MOISTURE DEPTH GAUGE

# OPERATING MANUAL

*2830 Howe Road*
*Martinez, California 94553*
*Telephone (510) 228-9770*
*Telex 17-1289 CPN-UD*
*FAX (510) 228-3183*

# MANUAL CHANGE NOTICE 503DR

## VERSION 503A-230

To take a standard count press: STD, step till the gauge displays "NEW STD?" and press ENTER.

In Format the gauge now allows a record to contain 0 to 99 keydatas and 0 to 99 readings.

Selftest has been removed from the Menu.

While taking a count the display shows "COUNTING".

While taking a reading in Log Mode, the display shows "COUNT N", where "N" is the number of the reading as defined in format and counts down to "1".

The displayed units are: CNT, RAT, PCF, GCC, %V, IPF, AND CPC.

There are now provisions for 16 calibrations. A calibration may be selected by pressing STEP until the number is displayed and pressing ENTER as described previously or by selecting directly. e.g. press CALIB, 12, ENTER to select the 12th calibration.

The Format command now displays the number of records of storage after the "SET FMT?" display. Press ENTER to complete formatting the gauge.

The version display now includes the model number. e.g. "503A-230".

The print dump format has been changed. The first line header include the new version number. In PRINT LP a top of form command is issued after the header and calibration information and before starting the date print out.

## WARRANTY

CPN products are guaranteed against defective material and workmanship for a period of eighteen (18) months from the date of receipt by customer, or a maximum of twenty-four (24) months from the date of manufacture, whichever comes first. Detector tubes, fuses, and batteries are guaranteed for (6) months from the date of shipment from CPN.

Upon their prepaid return, CPN will replace free of charge any part found to be defective within these warranty periods. CPN reserves the right to repair all defective parts at our factory, or authorized CPN service facility.

This warranty is void if inspection shows evidence of abuse, misuse, or unauthorized repair. This warranty covers only replacement of defective materials and workmanship. This warranty does not cover damage caused by exposure to excessive moisture.

If, for any reason, this unit must be returned to our factory for warranty service, please contact us for return authorization and shipping instructions. Include with the shipment: customer purchase order number, CPN Company invoice number and date, serial number of gauge and reason for return.

INSTRUCTIONS
TABLE OF CONTENTS
(White Section)


GENERAL

.1 INTRODUCTION
.2 SPECIFICATIONS
.3 INSTALLATION
.3.1 GETTING STARTED
.3.2 CABLE STOPS
.3.3 TUBE ADAPTERS
.4 OPERATION CAUTIONS

.0 OPERATION

.1 CONTROLS AND DISPLAY
.2 KEYBOARD LAYOUT
.3 KEYBOARD OPERATION
.4 BATTERY
.5 OPERATING PROCEDURES
.5.1 TAKING A READING
.5.2 TO LOG A READING
.6 STANDARD COUNT
.7 PRINT
.8 REMOTE OPERATION
.9 RS232C SERIAL LINK (HARDWARE DESCRIPTION)

SPECIAL

.1 CALIBRATION
.2 ERROR MESSAGES

APPENDIX

A COUNTING STATISTICS
B DRDUMP PROGRAMS
C CABLE WIRING DIAGRAMS


SOFTWARE VERSION 226, May 9, 1984

# 1.0 GENERAL

## 1.1 INTRODUCTION

The Model 503DR HYDROPROBE, NEUTRON DEPTH MOISTURE GAGE measures the sub-surface moisture in soil and other materials by use of a probe containing a source of high energy neutrons and a slow (thermal) neutron detector. The probe is lowered into a pre-drilled and cased hole (1.5 or 2 inch diameter). Hydrogen as present in the water in the soil slows the neutrons down for detection. The moisture data is displayed directly in units of interest on an above surface electronic assembly which is integral to the source shield assembly.

The gage is supplied with a 12 foot cable and five adjustable cable stops. Additional stops and longer cable lengths are available.

Upon retraction of the probe into the shield, the probe locks automatically in place for transportation.

The complete assembly is supplied with a plastic shipping and carrying container which contains; accessory items, cable, instruction manual, charger, and other materials which the operator may wish to carry.

PECIFICATIONS

| | |
|---|---|
| NCTION: | Sub-surface moisture measurements. |
| E: | 0 to 32% vol, (0.32 gm/cc), (20 pcf), (3.84 in/ft). |
| ECISION: | 0.24% at 24% vol at one minute. |
| UNT TIME: | 1, 4, 16, 32, 64, and 256 sec. |
| MP: | 0 TO 70oC operating. |
| WER: | AA NICAD batter pack (0.5 Ah) 8 cells. |
| TTERY LIFE: | 500-1000 Charge-discharge cycles. |
| NSUMPTION: | 6.5 mA avg. (allows more than 3000 each 16 sec counts). |
| CHARGE: | 14 hours at C/10 via wall charger. |
| SPLAY: | 8 character alpha/numerical Liquid-Crystal Display. Easily readable in direct sunlight. |
| TA STORAGE: | 3072 cells of; counts, identifiers, or keyboard entry of auxiliary values. Format operator programmable. 0-15 key and 0-15 count per record |
| ATA OUTPUT: | RS232C serial dump to external printer, computer, CRT or coupler. |
| ALIBRATION: | 8 ea user programmed (linear). |
| NITS: | User selectable: in/ft, pcf, gm/cc, % vol, cm/30cm, count and count ratio. |
| EUTRON SOURCE: | 50 mCi Americium-241/Be |
| CAPSULATION: | Double Sealed Capsule, CPN-131 |
| ELDING: | Silicon based paraffin |
| HIPPING: | Radioactive Material, Special Form, N.O.S., UN2974 Transport Index 0.1 Yellow II Label USA DOT 7A, Type A Package |
| SPECIAL FORM APPROVAL: | USA/0115/S |
| CONSTRUCTION: | Aluminum with epoxy paint or hard-anodize finish. Stainless steel wear parts |
| SURFACE UNIT: | 15.7#, 6.8"Wx7.0"Dx14.0"H (7.12),(172.7x177.8x355.6) |
| PROBE: Model -2 | 2.3#, 1.865" dia x 12.7"L (1.043), (47.4 dia x 322.6) |
| Model -1.5 | 1.7#, 1.500" dia x 12.7"L (0.771), (38.1 dia x 322.6) |
| CARRYING & SHIPPING: | 36.5#, 24"W x 13"D x 10"H (16.56), (609.6 x 330.2 x 254) |

## 1.3 INSTALLATION

### 1.3.1 GETTING STARTED

The stand-by power drain of the gage is less than the self-discharge of the NICAD cells thus eliminating the need for a power switch. The DR is always ON. When first received it is recommended that the gage be placed on charge overnight to insure starting with a full charge.

You will have to set the gage to a configuration to meet your field conditions. To assist in understanding the gage initially, it is shipped from the factory in the following configuration:

| | |
|---|---|
| UNITS | Inches per Foot |
| TIME | 1 second |
| CALIB | #1 Factory calibration in saturated and dry sand.<br>A (slope) approx 2.5 in/ft per countratio<br>and B (intercept) approx -.06 in/ft |
| STD | Standard count approx 10000 26 |
| FMT | 1 ID, 1 Keydata and 3 Depths allowing 279 records |

With the gage sitting on the nameplate on the shipping case press START. The gage should take a one second count and display the equivalent moisture of the wax in the shield. It should be approximately 2.4 inches per foot.

Most of the commands are READ/STEP/WRITE. That is, when first called up you read the display to see the current value, step to a new value and then write (enter) the new value into memory. Try this by using the following keystrokes to change the time from 1 to 16 seconds.

| **PRESS** | **DISPLAY** | |
|---|---|---|
| | READY | |
| TIME | TIME 1 | (Read the current value) |
| STEP | TIME 4 | |
| STEP | TIME 16 | (Step to a new value) |
| ENTER | READY | (Write it to memory) |

Do the same for Units, changing from Inches per Foot to % Volume.

| **PRESS | **DISPLAY** |
|---|---|
| | READY |
| UNITS | UNIT IF |
| STEP | UNIT CC |
| STEP | UNIT %V |
| ENTER | READY |

Take another count by pressing START. The measured result should be the same as above except that the count should take 16 seconds and the display should be approximately 20.0% moisture by volume (which is equivalent to 2.4 in per foot in the reading above).

Please read the remainder of this manual

ction 2.5.1 is task oriented and describes the steps to use the gage take readings. When you are ready to take it further and log adings, read section 2.5.2.

ctions 2.1, 2.2, and 2.3 are function oriented describing what each y does.

ctions 2.9 contain the necessary information to hardware interface the ge to a computer or printer.

ctions 2.7 and 2.8 cover the software interface information.

.3.2 CABLE STOPS

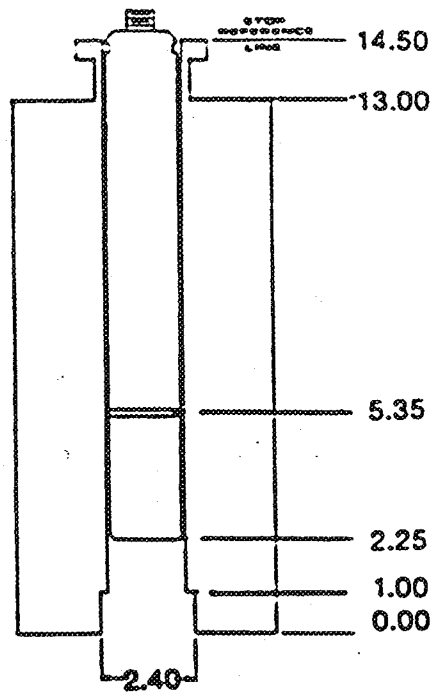



FIG 1.3.2-1

e gage is supplied with five each clamp cable stops. This will allow taking asurements at one foot increments in a ot zone up to five feet deep. For a eper root zone or for smaller increments der more stops. Fig 1.3.2-1 shows a oss-section of the gage. Use it to sition the first stop so that the mea- ement point on the probe (as indicated the band) is in the middle of the top ot of the root zone. Its actual location ill depend upon how high the access tubes tick out of the soil. Install all tubes he same distance.

or example, if the base of the gage is .0" above the soil and you want to take e first measurement at 6", place the top at 5.35 + 5.0 + 6.0 = 16.35" above he stop reference line.

.3.3 TUBE ADAPTER RING

he bottom of the gage contains an oversize hole to allow inserting an dapter ring with a diameter to match the type of access tubing being sed. The ring is secured by a screw through the front of the casting. nless specified otherwise at time of order, an adapter ring for alumi- um tubing will be supplied. Adapter rings for other type (e.g. iameter) are available from CPN Corp. or can be constructed locally.

## 2.0 OPERATION

### 2.1 CONTROLS AND DISPLAY

Most functions are directly entered by pressing the appropriate key. Options are reviewed by STEPing, and selected with ENTER.

| Key | Function |
|---|---|
| D-WET | Display latest wet density reading (501 only) |
| D-DRY | Display latest dry density reading (501 only) |
| WATER | Display latest moisture reading |
| | |
| UNITS | Select measurement units (CT,RO,PF,IF,GC,CC,%V) |
| TIME | Select counting time (1,4,16,32,64,256) sec |
| CALIB | Select calibration (1..8), and optionally: |
| COEFF | Enter coefficients directly |
| SLFCAL | Semi-automatic calibration |
| | |
| LOG | Log a tube site record |
| RCL | Recall a record for review |
| PRINT | Dump records to external device |
| PRINT CD | Dump to an active device (Computer Device) |
| PRINT LP | Dump to a passive device (Line Printer) |
| | |
| MENU | Select misc function: |
| SELFTEST | Self test of circuits (destructive RAM test) |
| BAUDRATE | Select baudrate (110,300,1200,2400,4800,9600) |
| ATTRIB | Set attributes for the Print LP dump. 3 ea Prefix, 3 ea Suffix, and a Top of Form. |
| SERNO | Display/Enter a four digit serial number |
| VERSION | Display software version |
| STD | Display/update standard count summary |
| FMT | Set record format, clear records |
| | |
| START | Take a reading |
| CLEAR(NO) | Clear, abort, "NO" |
| STEP | Next, skip, toggle |
| ENTER(YES) | Enter data, make selection, "YES" |
| | |
| STEP & CLEAR | Master Reset (Hold STEP down and press CLEAR) |

| Display | Function |
|---|---|
| "READY" | Gage is ready for operation. |
| "." | Decimal point in lower left indicates low battery condition. |
| "\|" | Bar in left character with no keyboard response indicates cutoff condition. |

## 2.2 KEYBOARD LAYOUT

```
+------------------------------------------------------------------------------+
|                                                  +-----+ +-----+ +-----+   |
| CPN CORP                          Model DR       |D-WET| |D-DRY| |WATER|   |
| +-----------------------------------------+      +-----+ +-----+ +-----+   |
| |                                         |      +-----+ +-----+ +-----+   |
| |                                         |      |UNITS| | TIME| |CALIB|   |
| |                                         |      +-----+ +-----+ +-----+   |
| +-----------------------------------------+      +-----+ +-----+ +-----+   |
|                                                  | LOG | | RCL | |PRINT|   |
|                                                  +-----+ +-----+ +-----+   |
| +-------+ +-------+ +------+ +-------+           +-----+ +-----+ +-----+   |
| | START | | CLEAR | | STEP | | ENTER |           | MENU| | STD | | FMT |   |
| +-------+ +-------+ +------+ +-------+           +-----+ +-----+ +-----+   |
+------------------------------------------------------------------------------+
```

## 2.3 KEYBOARD OPERATION

D-WET (501 ONLY)
Displays wet density using currently selected calibration and units (On a 503 returns to "READY").

D-DRY (501 ONLY)
Displays dry density using currently selected calibration and units (On a 503 returns to "READY").

WATER
Displays the most recent moisture reading in current units using current calibration e.g. "1234 CT". If number to be displayed is undefined (e.g. exceedes the display size) then "*.* CT" will be displayed.

UNITS
Display/Select measurement unit. Displays current unit e.g. "UNIT IF". To select new unit, STEP to desired unit and press ENTER. If CLEAR or another selection key is pressed, unit remains unchanged.

| Mne | Unit | Conversion |
|---|---|---|
| CT | counts/unit-time(16 sec disply) | n/a |
| RO | ratio (count/stdcount) | n/a |
| PF | lbs of water/cubic foot of soil | 62.428 |
| GC | gms of water/cubic cm of soil | 1.0 |
| IF | inches of water/ft of soil | 12.0 |
| CC | cm of water/30 cm of soil | 30.0 |
| %V | percent water by volume | 100.0 |

The conversion numbers are shown for reference only. The gage performs the conversion internally depending upon your selection of units. e.g. a readings in gm/cc is divided by 1.0 and multiplied by 12 to get an equivalent reading in inches per foot.

CALIB

Display/Select calibration (1 thru 8) and/or review/change its' coefficients.

Before pressing CALIB, select the appropiate units and time via the UNITS and TIME keys. If counts (CT) or ratio (RO) is the selected unit the gage will display "SET UNIT". If SLFCAL is to be used to take a count, select a time of 256 seconds for maximum precision.

TO SELECT A CALIBRATION

Active calibration is displayed on entry e.g. "CALIB 4". To select another calibration, STEP to the desired number and press ENTER. When the prompt "COEFFS ?" appears press CLEAR to return to "READY".

TO ENTER/CHANGE COEFFICIENTS WHEN THE COEFFICIENTS ARE KNOWN

Select the calibration number as above. When "COEFF ?" is displayed press ENTER. Coefficient "A" is the slope, "B" is the intercept in an expression of the form:

Display = A x (ratio) + B

Where ratio is count divided by standard count

Enter A and B using the same units as previously selected by the UNITS key.

The current "A" coefficient will be displayed. Press ENTER to accept it or change it via the numeral keys and press ENTER. Same for "B". Returns to "READY" after last coefficient entered.

TO ENTER/CHANGE COEFFICIENTS WHEN THE COUNTS ARE KNOWN OR TO BE DETERMINED

Select the calibration number as above. Press STEP till "SLFCAL ?" is displayed. Press ENTER.

| | |
|---|---|
| "M1 ____" | Enter first moisture value in the selected units. |
| "C1 ____" | Enter associated count or press START to take a count. ENTER to accept, START to retake. |
| "M2 ____" | Enter second moisture value in the selected units. |
| "C2 ____" | Enter associated count or START to take a count. ENTER to accept, START to retake. |

Either the low or high data pair may be entered first. When taking a count place the probe in the appropiate moisture standard before pressing START. After coefficients are computed and stored, display returns to "READY". To review the coefficients use "COEFFS ?".

LOG

Arms the storage mechanism to log a tube site record. As defined previously by the FMT key, each RECORD consists of 1 each ID, 0 TO 15 keypad entries, and 0 to 15 depths. ID number, keypad entries and depths start at the highest value and down count to 1. When LOG is first pressed the current record number is displayed. Press ENTER to use it as the default ID number or key in a meaningfull record number. The record number decrements from the maximum to 1, each time a new record is logged. The record number is thus an indicator of how many additional records may be logged.

Keypad fields are read/modify/write. i.e. it will first display what is stored in that location (normally blank for a new location). Key in a value and press ENTER to store the new value. Press CLEAR to abort a wrong key entry. A keypad field may be skipped by pressing STEP.

Moisture fields are stored the same except that value is from a count initiated by pressing START. It may be retaken but will only be stored and advanced to the next field when you press ENTER.

A record is not stored in the log until the prompt "DATA OK?" appears and ENTER is pressed. If at that time you press STEP instead, the display will step around to the beginning of the record allowing it to be viewed and edited. To accept an existing keydata or moisture value press ENTER or STEP. To change the data, write over the keydata field followed by ENTER or press START for a new count followed by ENTER. The corrected record is finally stored when you press ENTER while "DATA OK?" is displayed.

RCL

To review the record log. On entry displays ID number of last record logged. STEP back thru the log to the ID number of desired record and press ENTER, or enter ID number directly. i.e. 1234 ENTER. If the keyed in ID number does not exist, displays "NOT HERE". Press STEP to acknowledge and continue STEPing from last real ID. When desired ID is displayed press ENTER. Use the STEP key to move across the fields of the record (like a window moving across a tickertape).

Press CLEAR to step down the ID' s. Press ENTER to return to the more detailed level. At the outer level you see the IDs only, at the inner level the entire record.

PRINT

Dumps record log to external device via the serial connector. For "PRINT CD" press PRINT, ENTER. For "PRINT LP" press PRINT, STEP, ENTER.

PRINT CD

Output formatted to upload record log to a computer directly or via modem. Includes a line count and with each data line a checksum. Uses ACK, NACK software protocol to control transmission.

PRINT LP

Output formatted for readability. Contains same information as Print CD dump without the line count and the checksums and does not wait for a response.

MENU

Step down the menu choices and press ENTER to select a choice.

SELFTEST

Runs a comprehensive hardware check on the gage consisting of RAM test, ROM test, Counter test, Timer test, Display test and Keyboard test. The RAM test is destructive. Do NOT run it if the LOG data is important. Selftest takes about 2 minutes. You must watch the display test to see that all segments are the same. The keyboard test echos the key pad you touch. To complete the keyboard test press CLEAR twice. A successful test will display "TST OK". If an error occurs, an error message will be displayed at the end of that test. To acknowlwedge it and continue the remaining tests press ENTER. To abort any test press CLEAR during the test.

BAUDRATE

Allows setting the baud rate for transmission on the serial connector. When first selected, displays the baud rate currently selected. Use the STEP key to step to a new rate and press ENTER.

ATRIB

Allows setting attributes into the PRINT LP output for specific external equipment. Has provisions for 3 each characters at the beginning of transmission (prefix) and three each at the end (suffix). A typical prefix would be to transmit an ASCII decimal 15 to an EPSON printer to place it in the compressed mode. A typical suffix would be an ASCII decimal 26, which is reconized by a CP/M system as the end of transmission of a file of data.

A Top of Form character (TOF) is transmitted for each 60 lines of data.

| | |
|---|---|
| "PX1 000" | 1st prefix character |
| "PX2 000" | 2nd prefix character |
| "PX3 000" | 3rd prefix character |
| "SX1 000" | 1st sufix character |
| "SX2 000" | 2nd sufix character |
| "SX3 026" | 3rd sufix character |
| "TOF 012" | Top of Form character |

As shipped from the factory the prefix and two of the sufix characters are nulls (0). One of the sufix characters is a control Z (ASCII 26 for end of file in CP/M programs) and the TOF is a control L (ASCII 12). The ASCII characters are entered as their decimal values (0...127) by keying them in and pressing ENTER>

SERNO

Displays the last four numbers of the probe serial number. Press CLEAR to return to the READY display. The serial number may be change by keying in a new number followed by ENTER. This is useful when moving a surface electronic assembly from one gage shield/probe to another.

VERSION

Displays the gage software version (useful for service purposes).

TD

Displays standard count information and/or take a new std count. Initially displays the current moisture standard count (MS). Step to display previous moisture standard count (MP). Step again to display the chi-square ratio of the current standard (MCHI).

(See section 2.6 for detailed procedures) To take a new standard count press STD followed by START. The DR will take 32 each 8 second counts, with a 2 second warmup delay between each count (4.27 minutes of counting). During each count period the previous count number and count are displayed e.g."24-1234". When the last count is finished a NEW standard count based on the average of the 32 counts is calculated and displayed (it is displayed as an equivalent 16 second count to be consistant with a normal count display, and so will be twice the previously displayed 8 second counts).

Use the STEP key to view the CURRENT standard count (identified as previous at this point) and NEW chi-sq ratio (continuing to press STEP will cycle the display around the three pieces of standard count information). If the difference between the new and current standard counts and the value of the new chi-sq ratio are acceptable press ENTER to update the standard count information. If they are not acceptable press CLEAR to abort and take another new standard count.

To abort a standard count in progress, press CLEAR several times until "READY" is displayed. The standard count information will remain unchanged.

| Display | Description |
|---|---|
| "MS 1234" | Current standard count |
| "MP 1199 | Previous standard count |
| "MCHI 1.16" | Chi-square ratio (std-dev)/(sqr-root of std) |

FMT

Sets the record format, and clears the log space. On entry, displays the maximum number of possible records to be logged in the current format. e.g. "REC 279". Press ENTER. Key in the desired number of keydata entries (0 thru 15) and press ENTER. Do the same for depths (0 thru 15). When the gage displays "SET FMT?", be sure you want to do it and then press ENTER. This clear the log, sets the new record format, and start the storage at the top of the log area. Be sure you have dumped the previous information before clearing memory otherwise it will be erased. If you just wanted to view the current format but not clear it, press CLEAR to abort.

To display the maximum number of records under this new format, press FMT again. Press CLEAR to return the display to "READY" without changing or clearing the format.

## 2.4 BATTERY

The gage is powered by a replaceable NICAD battery pack (500 mAh capacity, 8 each cells). It is accessible by removing the four screws on the front panel. Also behind the front panel is a circuit breaker. The red indicator should be showing for the gage to operate.

The charger, which is supplied with the gage, charges at the rate of 50 mA. This C/10 rate will charge the gage overnight (14 hours) yet will not damage the cells if left on indefinitely. The red lamp on the charger should be ON and the charger should be warm to the the touch.

The 500 mAh capacity of these cells will allow 3000 or more 16 second readings on a full charge.

The gage should be charged any time the decimal point in the lower left of the display blinks or turns ON, or before going into the field two or more weeks since the last charge (the cells have a self-discharge rate of 1% per day at room temperature). It should also be charged prior to making a computer dump. The nominal battery voltage is 10.0V. The gage turns the low battery indicator ON when the voltage drops to 9.60V. It will not turn back OFF until the voltage has increased to 10.60V by recharging.

f the battery is allowed to discharge too low, the gage will automatically go into a cutout condition to protect the battery cells. The display will show the lower vertical segement in the first character. The eyboard will be inoperative. The gage goes into cutoff at 9.40V normally under load). The cutoff circuit is restored when the cells ave been recharged to 10.40V. This takes about 20 minutes with a C/10 harger. If cutoff occurs, charge the gage overnight and press CLEAR.

efer to the Service Section of this manual for more on battery cells.

## 2.5 OPERATING PROCEDURES

### 5.1 TAKING A READING

To take a reading lower the probe to the appropiate depth and press START. Before doing this you must select Units, Time and Calibration. If you select any units other than count, the gage must have a valid standard count.

```
+------------------------------------------------------------------------+
|                                              +------+ +------+ +------+ |
| CPN CORP                          Model DR   |      | |      | |WATER| |
| +-----------------------------------------+ +------+ +------+ +------+ |
| |                                         | +------+ +------+ +------+ |
| |                                         | |UNITS| | TIME| |CALIB| |
| |                                         | +------+ +------+ +------+ |
| +-----------------------------------------+ +------+ +------+ +------+ |
|                                              |      | |      | |      | |
|                                              +------+ +------+ +------+ |
| +--------+ +--------+ +--------+ +--------+ +------+ +------+ +------+ |
| | START | |        | |        | |        | |      | |      | |      | |
| +--------+ +--------+ +--------+ +--------+ +------+ +------+ +------+ |
+------------------------------------------------------------------------+
```

UNITS

The choice of display units will depend upon your use. Researchers will normally prefer grams per cubic centimeter or percent volume, while crop schedulers use inches per foot or centimeters per 30 centimeters. Counts are helpful for troubleshooting. It is the same data only differing by the conversion factor.

Once the units have been selected, then each time a count is taken the display will be in the units selected.

TIME

For a given counting rate the counting time interval determines the precision of the count. The longer the time, the more counts and thus the more precise the count. Correspondingly the longer the counting time the less measurement that can be made in a day. Thus the time interval is normally selected as the minimum time that will not sacrifice precision.

For scheduling type operation a count time of 16 seconds will provide sufficient precision to project the next irrigation date.

See the apendix section on Counting Statistics for a further discussion of precision.

CALIBRATION
The calibration will have been determined previously and the slope (A) and intercept (B) coefficients stored in one of the eight calibrations. Select the one that is appropriate for the soil and type of access tube.

TAKE A COUNT

Lower the probe to the desired depth and press START. While taking a count the gage will display the time, calibration, and units selected.

```
G16    1.IF
| |    | |
| |    | |---  Units selected as inches per foot
| |    |
| |    |---  Calibration Number 1 selected
| |
| |---  Time selected in seconds
|
|---  Go or Count in process
```

The gage will then display the measurement in the selected units. e.g. "3.88 IF".

The last reading may be displayed at any time, in the currently selected units and calibration, by pressing the WATER key.

2.5.2 TO LOG READINGS

Readings can be logged by the gage as they are taken in the field. Each tube site represents a record of information. Prior to storing any readings you must define the format of the tube site record. After readings have been logged, they can be recalled for display or dumped to an external device.

```
+-----------------------------------------------------------------------------+
|                                                  +-----+  +-----+  +-----+  |
| CPN CORP                         Model DR        |     |  |     |  |     |  |
| +----------------------------------------------+ +-----+  +-----+  +-----+  |
| |                                              | +-----+  +-----+  +-----+  |
| |                                              | |     |  |     |  |     |  |
| |                                              | +-----+  +-----+  +-----+  |
| +----------------------------------------------+ +-----+  +-----+  +-----+  |
|                                                  | LOG |  | RCL |  |     |  |
|                                                  +-----+  +-----+  +-----+  |
| +-------+  +-------+  +------+  +-------+      +-----+  +-----+  +-----+  |
| | START |  | CLEAR |  | STEP |  | ENTER |      |     |  |     |  | FMT |  |
| +-------+  +-------+  +------+  +-------+      +-----+  +-----+  +-----+  |
+-----------------------------------------------------------------------------+
```

FORMAT
Use the FMT key to format the data storage area to agree with the

tube conditions. For each access tube at which one record of data is stored, the format will allow 0 to 15 keydata entries and/or 0 to 15 tube depths (counts per tube). The gage always provides for an identifier number (ID) for each record and stores the selected calibration number (1-8).

The total memory space available is 3072 bytes. The number of bytes required in a record for each tube site is as follows:

| FIELD | BYTES |
|---|---|
| ID | 2 |
| CALIBRATION | 1 |
| KEYDATA | 2 |
| DEPTH (count) | 2 |

Thus a typical tube site record format of of one ID, one calibration number, one keydata, and three depths (counts), takes 11 bytes per record, and allows 279 records to be stored.

After the number of depths is entered the gage will display "SET FMT?". Press ENTER to set the new format or CLEAR to abort. Setting a new format clears all the data records. DO IT EACH TIME A NEW SET OF DATA IS TO BE STORED.

Press FMT, ENTER, ENTER, ENTER, CLEAR to view the number of records, keydatas and depths without clearing the data records.

LOG/TAKE MEASUREMENTS

Set units, time, calibration and format. Then to log a record of information, place the gage on the access tube and press LOG. The gage will display the number of the current record into which data is to be logged. Since it down counts it is also an indication of how many empty records remain.

You can use the gage generated number as the ID number to be stored by pressing ENTER. To enter your own ID number for this record (access tube) key in any number from 1 to 65,535 followed by ENTER. It may be meaningful to treat this number as more than one number. i.e. consider the first two digits as a farm number (allowing from 1 to 65 farms) and the last two digits as a farm field number (allowing from 1 to 99 fields on any farm). Enter the middle digit as 0 or use it to indicate an operator number from 1 to 9.

After entering the ID number the display will prompt for keydata entry e.g. "K1_____" (if selected by the FMT key previously). Keydata entries allow you to use the gage to key in auxiliary information such as temperature, rainfall etc. This feature helps eliminate errors in translating readings to note pads and then from the note pad to the computer. (It is recommended that all field data be hand recorded to prevent loss due to subsequent equipment failure).

Enter the keydata as a number from 0 to 65,535 followed by ENTER.

Again it may be treated as more than one piece of information. i.e. first two digits for temperature in degrees Celsius and the last two digits for rainfall in inches. A keydata field does not have provisions for decimal points. They must be implied, not entered directly.

Use any scheme which fits your field conditions. Just be consistant from record to record. The Irrigation Water Management Program available from CPN Corp. provides for entering the date for a series of readings by setting the ID to "0" and the first keydata to the date. e.g. 412 for April the 12th. Press ENTER without taking counts to skip the depth readings for this special record. All records following until the next ID of "0" are then access tube readings. The IWM program expects that the farm number times 100 plus the field number will be stored in the ID and the site number in the first keydata. e.g. for farm "1", field "2" and site "3" the ID would be 102 and the first keydata would be 3.

If you make an error in entering a number, press CLEAR and enter the correct number. If you press CLEAR more than once in succession it will cancel the record storage without saving any of the record and return to the "READY" display.

If the gage does not accept the number (e.g. you try and enter a decimal point) it will give a multiple beep and re-prompt. If it does accept the number it will prompt for the next keydata or if all keydatas are entered it will prompt for a moisture reading by displaying "TAKE M#" (# is the number of the depth position and will down count from the maximum number set via FORMAT to 1).

Lower the probe to the correct depth and press START. The gage will display during counting as follows:

```
L1    1.IF
||    |  |
||    |  |---  Units selected as inches per foot
||    |
||    |---  Calibration Number 1 selected
||
||---  Time selected in seconds
|
|---  Log Count in process
```

When the count is completed the gage will display "M#" and the value of the reading in the units selected e.g. "M3 2.6538". If the reading is acceptable press ENTER to store it. If not acceptable identify the reason and press START to take another. Thus the gage will only store a reading if you accept and enter it. The display will then prompt to take the next depth moisture reading. Move the probe and repeat the process by pressing START. Continue in this manner until all depths have been recorded.

If you want to skip a depth (e.g. the bottom depth is flooded) press STEP instead of START/ENTER. This is also useful if you have some tubes with five depths and some with only three. Format for five and skip two readings when on a tube with only three depths.

If the units "IF" or "CC" have been selected then after the last depth has been entered or stepped over, the gage will totalize and display the TOTAL MOISTURE in the root zone in inches or cm e.g. "TM 16.437".

Press STEP or ENTER and the gage will display "DATA OK?". Press ENTER to log all the data for this record. The display will return to "READY". If the data is not correct press STEP until the bad data is displayed (the display will start with the ID and skip across the record). Correct it by a keydata entry or taking and entering a new count. If you press CLEAR when "DATA OK?" is displayed then the logging of that record will be aborted and all data for that record cleared.

Use the ENTER or STEP key to skip to the keydata you want to change or take a new count. When you again reach the end of the record and "DATA OK?" is displayed press ENTER to log that record.

RECALL A RECORD

Normally the stored data will be dumped to a printer or computer. It may also be recalled to the display by the RCL key. When first entered it will point to the last ID stored. Either use the STEP key to step up the ID list (it steps back thru the list and circles around at the begining) or key in a specific ID and press ENTER. Use the step key to move across the record. If you continue pressing STEP the display will advance up to the next record and then across etc.

2.6 STANDARD COUNT

The standard count is a measurement of the hydrogen in the wax in the shield. By taking it in exactly the same manner each time, it provides two means for checking the validity of the counting function.

1) By comparing it with the previous standard count to see that it has not changed more than an acceptable amount, it is an indication of acceptable drift of the electronics. Americium-241 has a one-half life of 458 years. It's decay rate is negligable.

2) By taking it as a series of short counts rather than one long count and verifying that its statistical distribution is normal, it is a means of checking that noise is not influencing the count.

PREVIOUS STANDARD COUNT

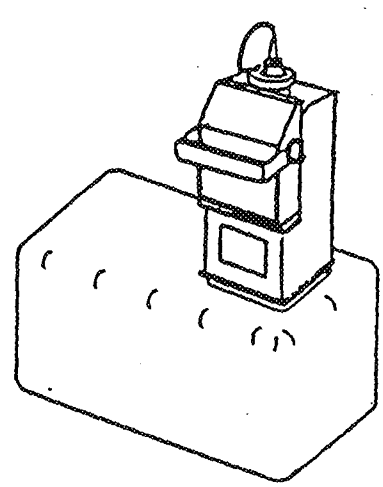
Whenever a new standard count is taken, the DR automatically holds the current standard count in the previous count memory. This allows for comparing the new count with the current count. The difference between the two counts should be within 0.707 of the square root of the average of the two counts 95% of the time.

> Example: The current standard counts is 14400 while the previous standard count is 14450. The difference between the two numbers is 50. The square-root of the average of the current standard count is 120.1 (one standard deviation). Since 50 is less than 85, (0.707 times 120), the two counts are within acceptable limits and there is no reason to believe the gage is malfunctioning.

·f it is more or if it is continuously changing in the same direction it ndicates that service may be warranted.

AKING A STANDARD COUNT

ith the case on the ground, place the gage in he CPN nameplate depression on the top of the ase. No other radioactive sources should be ithin 30 feet of the gage and no source of ydrogen should be within 10 feet of the gauge. he operator should stand back 10 feet after tarting the reading.



ɔ initate a new standard count press STD and nen START.

ne wax in the shield is not an infinite ɔlume. Thus a standard count taken in this anner is subject to surrounding conditions. It ; important that the standard count is taken ı the same conditions as that used to establish the calibration and that the conditions are the same each time.

A more stable method to take a standard count in an access tube installed in a 30 gallon or larger water barrel. To use the factory calibration but change to a new method of taking a standard count, modify the "A" calibration slope term by the ratio of the new standard count and the factory standard count. e.g. the original factory standard count was 11,000 with an "A" slope of 2.6, while the new water barrel standard is 33,000. The new "A" coefficient should be:

2.6*(33,000/11,000)=7.8

The verification reading of the wax in the shield as per section 1.3.1 should be the same.

When a standard count is started, the gage will take 32 each 8.0 second counts, turning the HV power supply to the probe on with each count. With each count, the display will show the count number (32, 31, 30,......,1) followed by the actual 8 second count e.g. "30 7200". When the 32nd count is completed the <u>NEW standard count is displayed e.g. "MS 14400".</u> It is normalized to a 16 second count time, the same as a normal display count.

Press the STEP key to view the CURRENT standard count e.g. "PS 14500". Press the STEP key again to view the Chi-Sq Ratio of the NEW count e.g. "MCHI 1.16". Continuing to press STEP will cycle the display thru the three pieces of standard count information. To update the standard count press ENTER while the display is in this loop. The current standard count will be stored as the previous standard count and the new standard count will be stored as the current standard count.

(Note that the previous standard count viewed above is actually the current standard count until you press ENTER to accept the new standard count).

To exit STANDARD without updating the standard count press CLEAR. To abort a standard count in process press CLEAR several times until "READY" is displayed

If the gage is connected to a printer via the serial link (see section 2.9), individual counts and summary information will be printed

```
SN 4860

-STATCT-
32-4398
31-4461
30-4469
29-4267
28-4572
27-4349
26-4360
25-4467
24-4389
23-4407
22-4498
21-4481
20-4497
19-4363
18-4575
17-4513
16-4471
15-4407
14-4390
13-4411
12-4457
11-4463
10-4471
9- 4414
8- 4508
7- 4452
6- 4441
5- 4489
4- 4410
3- 4454
2- 4479
1- 4423

AVG   4444
CHIR  0.95
MSTD  8895  (AVG * 16/8)
```

FIG 2.6-1

ɔut as shown in fig 2.6-1

ISCUSSION

aking such a series of 32 counts will result in a distribution of ounts around a central value. The standard deviation is a measure of he spread of these counts about that central value. For a random evice, such as the decay of a radioactive source, the ideal standard eviation should be equal to the square-root of the central value.

f the gage is working properly, then the measured standard deviation nd the ideal standard deviation should be the same and their ratio hould be 1.00. The Chi-Squared test is used to determine how far the atio can deviate from 1.00 and still be considered acceptable. This is imilar to expecting heads and tails to come up equally when flipping an nbiased coin but but accepting other distributions when only fliping a mall number of times.

or a sample of 32 counts, the ratio should be between 0.75 and 1.25 for 5 % of the tests. Note that even a good gage will fail 5 out of every 00 tests. If the ratio falls too consistently outside, it may mean that he counting electronics is adversely affecting the counts. Generally he ratio will be high when the electronics is noisy. This might be due o breakdown in the high voltage circuits or a defective detector tube. he ratio will also be high if the detector tube counting efficiency or he electronics is drifting over the measurement period. i.e. The aver- ge of the first five counts is significantly different than the aver- ge of the last five counts.

t will be low when the electronics is picking up a periodic noise such s might occur due to failure of the high voltage supply filter. This hould be accompanied by a significant increase in the standard count ver its previous value.

## 2.7 PRINT

Outputs the contents of the record log to an external device (computer, CRT Terminal, modem, printer, etc) via the RS232C serial interface connector.

Two forms are available:

PRINT CD -- for dump to an active device such as a computer (or computer via a modem). Each line of data includes a check sum and requires a software response from the computer to insure proper transmission of data.

PRINT LP -- for dump to a passive device such as a printer or CRT Terminal. Same as the Print CD except no checksum, and the next line of data is transmitted without waiting for a response from the receiving device. Also the data is formatted for ease of readability and header information is included.

### PRINT CD

A simple software ACKNOWLEDGE/NEGATIVE-ACKNOWLWDGE handshaking scheme (ACK/control-F, NACK/control-U) allows the external device to control the dump: ACK echoed in response to a received line causes transmission of the next line, while NACK causes retransmission of the same line. ACK may be echoed as often as necessary to receive an error free line. Characters other than ACK, are by default NACK. If the DR does not receive a reply within 60 seconds after sending the carriage return and line feed (CRLF) at the end of each line, a default ACK is assumed and the next line is transmitted. The computer should not echo the DR transmission.

The following table shows how long in milliseconds it takes to transmit one character at each of the possible baud rates. The program in the computer must be fast enough to receive, process and be ready for the next character within this time to insure not missing any characters. (See also section 2.9 for hardware handshaking which allows control of the DR transmission on a character by character basis).

| BAUD RATE | BIT ms | CHARACTER ms |
|---|---|---|
| 110 | 9.091 | 100.0 |
| 300 | 3.333 | 36.67 |
| 1200 | 0.8333 | 9.167 |
| 2400 | 0.4167 | 4.583 |
| 4800 | 0.2083 | 2.297 |
| 9600 | 0.10417 | 1.1458 |

It takes approximately 100 ms after an external device has transmitted an ACK or NACK, for the DR to respond and transmit another line of data.

Each dump line consist of a series of fields separated by commas, and terminated by CRLF. The fields are variable in number and width. The last field is a checksum determined by summing the ASCII decimal value of each of the characters in the line up to and including the last comma.

A received line whose computed checksum agrees with the transmitted checksum is good and should be echoed by ACK, else a loss of data is implied and NACK should be echoed.

As each line is being transmitted, (or retransmitted) its' line number is displayed on the DR. The line number down counts, giving an indication of the lines remaining, e.g. "LINE 123".

PRINT CD Format

The Print CD dump consists of 4 parts:

| | |
|---|---|
| Line 1 | Line count (N+10), gage identification and record format. |
| Line 2-9 | 8 calibrations. |
| Line 10-N | N records |

Line 1: Gage identification and format

```
Lines,503DR,Sn,Unit,Mstd,k,d,Chk
  |     |    |  |    |   | |  |--- Modulo 65536 checksum
  |     |    |  |    |   | |--- Depths per record (0..15)
  |     |    |  |    |   |--- Keydatas per record (0..15)
  |     |    |  |    |--- Standard count (0..65535)
  |     |    |  |--- Measurement unit (CT,RO,IF,CC,GC,%V,PF)
  |     |    |--- Probe serial number (0..9999)
  |     |--- Gage model number
  |--- Total lines to be transmitted (10..1033)
```

Line 2 - 9: 8 Calibrations

```
Cal,A,B,Chk
 |  | |  |--- Modulo 65536 checksum
 |  | |--- Intercept (real number)
 |  |--- Slope (real number)
 |--- Calibration number (1..8)
```

ne 10 - N: N Records

```
 Cal,K(k),...K(1),M(d),...M(1),Chk
  |   |         |  |         |  |---  Modulo 65536 checksum
  |   |         |  |         |
  |   |         |  |         |---
  |   |         |  |              .  d Depth moistures, M(d) real
  |   |         |  |              .
  |   |         |  |-------------
  |   |         |
  |   |         |---
  |   |                 .  k Keydatas, K(k) (0..65535)
  |   |                 .
  |   |-------------
  |
  |---   Record calibration number (1..8)
---   Record identification (0..65535)
```

file image of a PRINT CD dump is shown in Fig 2.7-1. Note that all ıta fields are separated by commas allowing easy use of input atements in BASIC or FORTRAN programs.

```
16,503DR,9999,IF,10000,2,4,1427
1,3.0,-0.06,567
2,2.5,-0.055,624
3,3.0,-0.08,571
4,3.5,-0.06,575
5,1.1,0.0,457
6.0.0,0.0,470
7,0.0,0.0,471
8,0.0,0.0,472
5263,1,0,0,0.0,0.0,0.0,0.0,1273
11001,1,20,5,6.804,4.946,6.65.3.31,1716
11002,1,20,0,3.386,1.15,1.097,1.61,1699
11003,1,20,1,2.225,1.822,1.826,1.702,1796
11004,1,21,5,2.887,1.855,1.966,2.191,1830
5273,1,2,0,0.0,0.0,0.0,0.0,1276
7003,1,22,15,3.41,4.442,4.135,4.082,1758
```

FIG 2.7-1

he print program requires that the computer be up during the dump. This laces a heavy drain on the battery. Charge the battery before dumping. f you believe the pack is up but not sure, connect the charger during he dump. If the cutout circuit turns on during the dump, the data is ot lost. Charge the gage for about an hour and then re-initiate the ump.

me samples of computer programs as shown in Appendix B. The ones in SIC will typically operate up to 300 baud. The assembly language call or the actual transfer of data that can be used to 9600 baud.

ıch computer system will require special considerations. Most operating ʼstems and high level languages are not written for real time ɹeration. For example one BASIC interperter does not require defining a ring length but changes its length as data input requires it. For a ısiness application this is convenient, but if it occurs while ıputting a record of information from the DR, some characters will be ·st. By including an assembly program control of the hardware ENABLE put to the DR this can taken care of, but such hardware control is not ʼssible with a modem.

INT LP

dump to a printer or a terminal contains the same information as the INT CD dump except that; no checksums, no line count and it is rmatted for readability with a header and Top of Form command every 60 nes. Print LP also transmitts three control characters at the begining d three at the end of the transmission. These sign on and sign off aracters may be used to set external devices such as a printer to a sired configuration. e.g. compressed print. These attributes along th the character reconized as top of form (TOF) are set via ATTRIB, a b-menu of MENU.

nes of data are transmitted one after another without waiting for an K/NACK response. The receiving device should NOT echo the ansmission.

typical PRINT LP printout is shown in Fig 2.7-2.

| MODEL | S/N | UNIT | MSTD | KDATA | DEPTH |
|---|---|---|---|---|---|
| 503DR | 9999 | IF | 10000 | 2 | 4 |

| CAL | A | B |
|---|---|---|
| 1 | 3.0 | -0.06 |
| 2 | 2.5 | -0.055 |
| 3 | 3.0 | -0.08 |
| 4 | 3.5 | -0.06 |
| 5 | 1.1 | 0.0 |
| 6 | 0.0 | 0.0 |
| 7 | 0.0 | 0.0 |
| 8 | 0.0 | 0.0 |

| ID | CAL | K2 | K1 | M4 | M3 | M2 | M1 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 5263 | 1 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11001 | 1 | 20 | 5 | 6.804 | 4.946 | 6.65 | 3.31 | 21.71 |
| 11002 | 1 | 20 | 0 | 3.386 | 1.15 | 1.097 | 1.61 | 7.243 |
| 11003 | 1 | 20 | 1 | 2.225 | 1.822 | 1.826 | 1.702 | 7.574 |
| 11004 | 1 | 21 | 5 | 2.887 | 1.855 | 1.966 | 2.191 | 8.899 |
| 5273 | 1 | 2 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 7003 | 1 | 22 | 15 | 3.41 | 4.442 | 4.135 | 4.082 | 16.07 |

FIG 2.7-2

ile PRINT CD is prefered because of it's handshaking, PRINT LP can be ed to make a passive data transfer to a computer. For a CP/M based system with a reader port, set the baud rates to agree, set a Control Z (ASCII decimal 12) attribute in one of the three suffix characters, connect the DR to the serial port defined as RDR: (see section 2.9), and type in the computer while in CP/M:

>PIP DR503.DAT=RDR:

Then press PRINT, STEP and ENTER on the DR.

The data in the DR will transfer to the file named DR503.DAT. It will be a literal file. You will have to strip out header information etc.

## 2.8 REMOTE OPERATION

The DR may be operated remotely via the RS232C serial connector. Set the DR and the external device to the same baud rate. If the DR is in the command mode ("READY" is on the display) then any character on the serial input line will activate the DR without causing any action. The appropiate remote control character from the following table should then be sent to the DR. Because of the debounce software in the DR, the following character should be spaced at least 100 milliseconds but not more than 60 secondsfrom the activate character. The DR will perform the command and shut down.

********** ASCII CHARACTERS **********

| INPUT CHAR | 503DR KEY |
|---|---|
| g | START |
| DEL | CLEAR |
| LF | STEP |
| CR | ENTER |
| w | D-WET |
| d | D-DRY |
| h | WATER |
| u | UNITS |
| t | TIME |
| c | CALIB |
| l | LOG |
| r | RCL |
| p | PRINT |
| m | MENU |
| i | SELFTEST |
| b | BAUDRATE |
| o | ATTRIB |
| n | SERNUM |
| v | VERSION |
| s | STD |
| f | FMT |
| 0-9 | 0-9 |
| z | STEP & START (enter monitor for maintenance purposes) |
| a | MEM R/W |
| k | MEM DMP |
| e | RUN PGM |
| x | BURN IN |

Control R Place the DR in the terminal mode (power up allowing it to receive further ASCII command characters. The DR will return to the normal mode 60 seconds after it receives any command unless a new command is received within that time. While in the terminal mode all characters sent to the display will also be transmitted on the serial output line).

These commands can be used to control the DR from a CRT terminal or a special program can be written to control the DR from a computer.

Control-R is a special command that places the DR in the remote terminal mode. While in the remote terminal mode all information which appears on the DR display will also be sent on the serial output line where it can be received by the control device. The DR will stay in this mode for 60 seconds after the last command. If a sequence of commands are separated by more than 60 seconds it will be necessary to send another Control-R.

r CP/M based systems with a reader/modem serial port, the XCOM command can be used to control the DR from the computer keyboard.

Example: To cause the DR to start a count send:

gg (lower case "g", 100 millisecond delay then lower case "g")

The first "g" (or any character) activates the DR. The second "g" is reconized as the equivalent of pressing the START key.

Example: To set the Time to 16 seconds:

| | DR DISPLAY | SERIAL OUTPUT |
|---|---|---|
| ^R | READY | |
| ^R | READY | |
| t | TIME 1 | TIME 1 |
| LF | TIME 4 | ––– 4 |
| LF | TIME 16 | ––– 16 |
| CR | READY | READY |

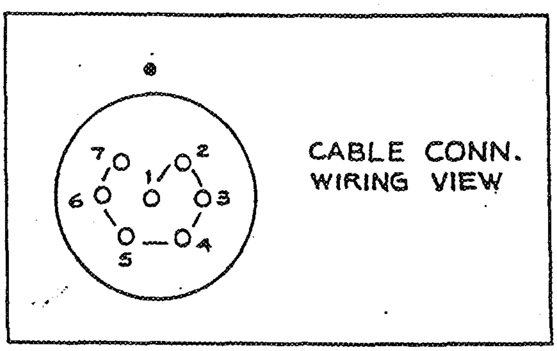
The first "^R" activates the DR. The second places the DR in the remote terminal mode. "t" causes the current time to be displayed and sent to the external device. If the external device is a terminal then the user ust view the display and key line-feeds (STEP commands) till the desired time is displayed then key a carrage return (ENTER command). If the external device is a computer, the program in the computer must do the same (the ––– shown above are actually backspace characters). The DR will return from the remote mode to the command mode 60 second after the CR or last command is sent.

## :.9 RS232C SERIAL LINK (hardware description)

'he DR has the capability of two way communications over a serial link. 'his allows; 1) the data stored in the DR RAM memory to be converted to ıard copy using a printer, 2) the data to be dumped to a computer for ;torage and further processing before printing a hard copy report, and ·) allows the DR to be controlled by the computer or a CRT terminal. The ıccess to this serial link is through the ACCESSORY CONNECTOR located on he front of the surface electronic assembly.

ACCESSORY CONNECTOR

| PIN | FUNCTION | |
|---|---|---|
| 1 | +10 V | +10 V from the DR for use by external equipment (protected by the internal circuit breaker) |
| 2 | GROUND | |
| 3 | SERIAL DATA OUT | Serial data from the DR to an external device |
| 4 | SERIAL DATA IN | Serial data to the DR from an external device |
| 7 | ENABLE | Control line from an external device to the DR. When open or high the DR will transmit the next character. When low the DR will hold transmission of the next character until ENABLE goes high. |




he DR transmits -4.0 volts for a MARK and +10 volts (battery voltage ctually ranges from 8 to 12 volts) for a SPACE.

| NAME | VOLTS | LOGIC | RS232C SPEC |
|---|---|---|---|
| ***** | ***** | ***** | *********** |
| SPACE | 10 V | HIGH | +3 TO +25V |
| MARK | -4 V | LOW | -25 to -3V |

he serial input to the DR accepts the standard RS232 voltage swing.

'he ASCII code is 11 bits composed of: one start bit, 7 data bits, one ·arity bit which is always transmitted as a mark and ignored on eceiving (some users refer to this as 8 data bits and no parity), and 2 top bits (the DR sends two stop bits and will accept one or more stop ts).

;232C defines connector types, pin assignments, signal voltage levels ·· timing for communications between a piece of data communications ipment (DCE) and a piece of data terminal equipment (DTE). The con- :ctor should be a DP25S (female) for the DCE and DP25P (male) for the TE. The DTE transmits on pin 2 and receives on pin 3. The reverse is rue for DCE equipment.

S232C has worked well when a piece of terminal equipment was working ith a modem. It has not been implemented consistantly when two pieces f terminal equipment are interconnected and the equipment designer must efine one of them as communications equipment. e.g. when a computer rives a printer, which is the DCE and which is the DTE? All ombinations of male/female connectors and transmission/receiving pins re found.

he following 6 ft long cables, including both a male and female version re available from CPN Corp. Also available are cable parts. Unless you ave provisions for soldering the small terminals in the circular con- iector with 26 AWG wire, it is suggested that you order the unterminated :able for special external device connector applications.

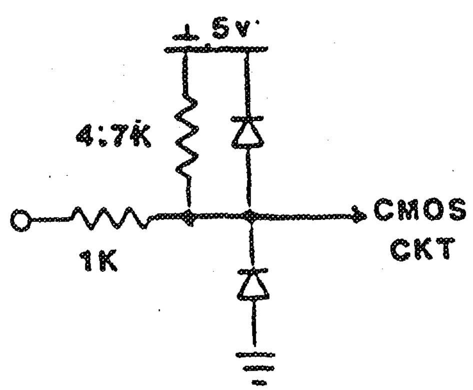
| PART NO | DESCRIPTION | MATES WITH |
|---|---|---|
| ******* | ******************* | ********** |
| T501544 | Cable, RS232C/DP25P | DP25S |
| C501516 | Cable, RS232C/DP25S | DP25P |
| T501575 | Cable, RS232C/unterminated | |
| RG18307 | Connector, ch, 7pin | |

The wiring of these cables is shown in Appendix C, along with some specific hardware configurations. If your configuration does not fit any of these cables available from CPN, order one with the proper connector type (male or female). Then rewire the pins as required.

The ENABLE LINE is available for hardware control of the transmission on a character basis. Most external equipment require the ENABLE line wired to pin 4 of the DP25 connector for an RTS protocol. On some it will be necessary to wire it to pin 20 for a DTR protocol.

If hardware handshaking is not required, leave the ENABLE line open. The DR has an internal pull up to place it in the proper state. The circuit for the ENABLE input (also the serial input) is shown in fig 2.9-1.

FIG 2. 9-1




The input control pins to the external device should be wired to either the mark or space condition as appropiate to allow data to flow.. Typically this will involve wiring pin 5 (CTS) and pin 6 (DSR) to the space (+10 V) condition.

## 3.0 SPECIAL

### 3.1 CALIBRATION

The neutron probe is a source of fast or high energy neutrons and a detector of slow or thermal neutrons. The fast neutrons are slowed down by collisions with the nucelus of matter in the soil and then absorbed by the soil matter. Since the mass of the nucleus of hydrogen is the same as that of a free neutron, the presence of hydrogen will result in a high field of thermal neutrons. Heaver elements will also slow down the neutrons but not nearly so effective. While it takes on the average only 18 collisions with hydrogen, it take 200 with the next element normally found in agro soil.

The thermal neutrons are continually being absorbed by the matter in the soil. Boron for example has a high affinity for thermal neutrons. The resulting thermal neutron flux will depend upon a number of factors both creating and absorbing thermal neutrons, but most importantly will be how much hydrogen is present. The neutron probe may thus be used as a measuring device for moisture in the soil but it may require calibration for local soil conditions.

### FIELD CALIBRATION

A field calibration requires the probe, a volume sampler, a scale and a drying oven. Install the access tube in a representative point in the soil. Take probe readings in the tube and volume samples in pairs around the tube. Take them at the same depth and within a foot or two of the tube.

Seal the volume samples in a sample can or plastic seal bag immediately after removing from the soil. Be carefull not to compact the surrounding soil when taking the samples. Ideally 20 such measurement pairs should be taken over a range of moisure conditions.

An alternate method is to use a sampler of smaller diameter than the tube and take volume samples at each depth while making the hole to install the access tube. Then take probe readings at the same depths. This has the advantage that the calibration is performed on the tube to be used for scheduling.

Another alternate, popular with irrigation schedulers is to only take two measurement pairs, one pair at field capacity and a second at a soil moisture condition near 50% depletion.

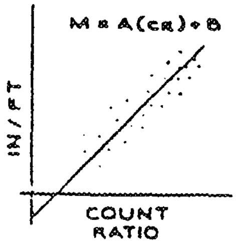



FIG 3.1-1

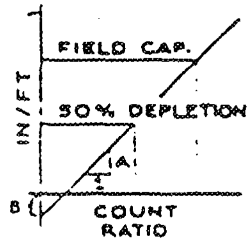



FIG 3.1-2

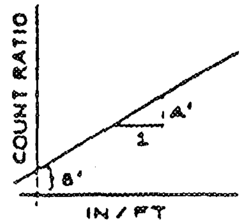



FIG 3.1-3

Weigh the soil samples wet and dry (24 hrs at 105 deg C in a vented oven). Calculate the moisture by weight and the dry soil density and then combine to determine the soil moisture content in inches per foot as follows:

$$\text{inches per foot} = \frac{Ww - Wd \ \text{(gm water)}}{Wd \ \text{(gm soil)}} \times \frac{Wd \ \text{(gm soil)}}{V \ \text{(cc soil)}} \times \frac{1 \ \text{(cc water)}}{\text{(gm water)}} \times 12$$

Using linear graph paper plot the probe readings in count ratio. versus the volume samples in inches per foot.

Fit the graph to a straight line. For a scatter diagram of 10 to 20 reading pairs do a linear regression on a hand calculator. For only two pairs use the following equations to determine the slope and intercept.

$$\text{slope} = A = \frac{MH - ML}{RH - RL}$$

$$\text{intercept} = B = ML - A \times RL$$

$$\text{then:} \quad m = (A \times r) + B$$

where:

- m = moisture in inches per foot
- r = count ratio
- MH = high moisture value in inches per foot
- ML = low moisture value in inches per foot
- RH = probe count ratio at the high moisture value
- RL = probe count ratio at the low moisture value

Example: A field capacity of 3.8 in/ft gives a ratio of 1.500, while 50 percent depletion gives a ratio of 0.77.

$$A = \frac{3.8 - 1.90}{1.5 - 0.77} = 2.603 \quad \text{in/ft/countratio}$$

$$B = 1.9 - 2.603 \times 0.77 = -0.1043$$

OR

$$m = 2.603 \times r - 0.1043$$

Perform the following keystrokes to enter this calibration into calibration number 2.

| KEY | DISPLAY |
|---|---|
| ****** | ******** |
| | READY |
| UNITS | UNIT CT |
| STEP | UNIT RO |
| STEP | UNIT IF |
| ENTER | READY |
| CALIB | CAL 1 IF |
| STEP | CAL 2 IF |
| ENTER | COEFFS ? |
| ENTER | A *.* |
| 2.603 | A 2.603_ |
| ENTER | B *.* |
| -.1043 | B -.1043 |
| ENTER | READY |

The DR defines the slope and intercept with water on the vertical axis and ratio on the horizontal axis as shown in Fig 3.1-2. If you data has been plotted with the axis reversed as shown in Fig 3.1-3, it will be necessary to transpose the slope and intercept terms before entering in the DR.

$$A = 1/A'$$

$$B = B'/A'$$

## LABORATORY CALIBRATION

· a laboratory calibration two known calibration points are needed. A high calibration standard might be a barrel of sand saturated with water (typically 0.32 gm/cc. i.e. 0.32 grams of water per cubic centimeter of soil or 32% water by volume or 3.84 inches of water per foot of soil). A low standard of dry sand would be 0.0 gm/cc.

Set the gage to the desired units and select a 256 sec count time. Use the SLFCAL feature of the probe. Place the probe in one of the two known moisture standards. The display will prompt for the known moisture density of the standard. Enter it in the units selected e.g. 3.88 ENTER. If count or ratio has been selected as the units, an error message will be displayed.

Pressing START will cause the gage to take and store a 256 second reading. When the count is completed move the probe to the second moisture standard. The display will prompt for the moisture density of that standard. Press START to take a 256 second reading in the second standard. When the count is completed, the gage will calculate and store the slope and intercept coefficients for the calibration in the selected units. Use "COEFF ?" ENTER to view them. Record them in your note book for future reference.

This is how the factory calibration was determined. It will be applicable for sandy soils with no significant minerals or organics. It can also be used for relative measurements. e.g. measuring a field before and after a known irrigation will allow determining how much was applied versus how much the probe measures before and after, thus calibrating the probe to that field.

## RANGE

The linear calibration supplied with the DR is useful over the most commonly used mositure range, 0 to 33%. For special operation in moisture percentages higher than this it is necessary to have a special calibration. Fig 3.1-4 shows a high range calibration. If field data is not available, a count in a water barrel can be used.

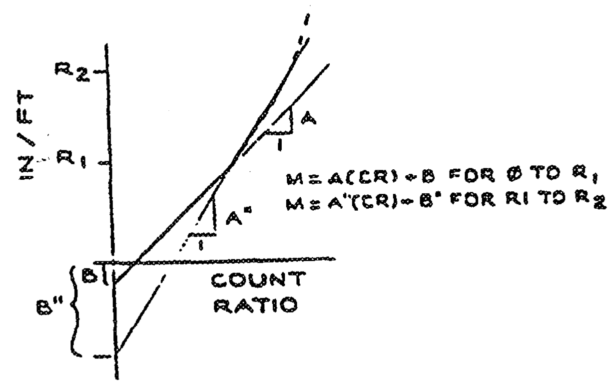



FIG 3.1-4

### 3.2 ERROR MESSAGES

If an error occurs in the DR, then the function that was being performed is aborted, and an error description or number is displayed (the gage is actually in the READY mode). Errors that may occur in the normal operation of the gage, will display a descriptive message. You should take corrective action as appropiate.

Equipment errors that should seldom occur will display a descriptive message or "ERR" followed by a number of 100 or above. If such an error number occurs, contact the factory or local service center.

TABLE -- ERROR MESSAGES

Operating errors:

| | |
|---|---|
| NO STDCT | No moisture standard count. Take a new standard. |
| FULL | Record log full. PRINT-out record log, and clear via FORMAT. |
| NOT HERE | ID entered into RECALL does not exist. Enter correct ID. |
| EMPTY | Record log empty when RECALL pressed. Load record(s) via LOG. |
| NO DATA | Record log empty when PRINT pressed. |
| SET UNIT | Calibration coefficients underfined for CT or RO unit. Change UNIT. |

Internal Check (hardware) errors:

| | |
|---|---|
| RAM XXXX | Non-destructive ram test failure at address XXXX. |
| ROM XXXX | Program memory checksum error. XXXX is the non-zero sum. |
| EEP XXXX | EEPROM read after write failure at address XXXX. |
| CK X.XXXX | Timer clock test period error. \|1 - X.XXXX\| > 0.01 seconds |
| MCTR ERR | Moisture counter failure. |

Program traps:

| | |
|---|---|
| I DIV 0 | Integer divide by zero. |
| DIV BY 0 | Real divide by zero. |
| NEG ROOT | Square root of negative number. |
| PBUS ERR | Pcode buss error. |
| EEP XXXX | EEPROM read after write failure at address XXXX. |
| ERR 100 | Computer bus error, underfined restart. |
| ERR 102 | Message number too big. |
| ERR 108 | Real display roundup exponent underflow. |
| ERR 109 | Onclear pstack pointer greater than current pstack pointer. |
| ERR 110 | Onclear machine stack pointer greater than current machine stack point |
| ERR 113 | Undefined pcode. |
| ERR 116 | Spurious timeout. |
| ERR 117 | Pcode pointer underflow (machine stack running pcode). |
| ERR 120 | Onclear stack underflow. |
| ERR 201 | Depth index too big. |
| ERR 203 | Record index too big. |
| ERR 204 | Count too big to store in record. |
| ERR 217 | Spurious initialization. |

# APPENDIX

# COUNTING STATISTICS

## 1.0 General

Radioactive decay is a chance process. For Cesium-137 which has a half-life of 30 years, it can be expected that in 30 years one-half of the material will have decayed, but in the next minute exactly which atoms will decay and exactly how many will decay is only by chance. Repeated measurements with the gage will thus most likely result in a different count for each measurement. A typical set of 32 such measurements is snown in Fig A-1.

Fig A-2, shows the distribution of these counts. The two characteristics of interest are: 1)The average value (also called measure of central tendency or mean) and 2)How wide the counts spread around this average.

Mathmatically the average value is defined as:

$$\boxed{\bar{x} = \frac{\sum x}{n}}$$

The width of the spread is defined by a term called standard deviation.

$$\boxed{s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}}$$

Or an alternate form useful on calculators

$$\boxed{s = \sqrt{\frac{n(\sum x^2)-(\sum x)^2}{n(n-1)}}}$$

where:

- $s$ = standard deviation of the sample
- $x$ = count (value of each sample)
- $\bar{x}$ = average of the sample
- $n$ = number of measurements in the sample

The above describes the average value and the standard deviation of a sample from a population. They are an approximation to the true average value and true standard deviation of the population.

SN 4660

-STATCT-
32-4398
31-4461
30-4469
29-4267
28-4572
27-4349
26-4360
25-4467
24-4389
23-4407
22-4498
21-4481
20-4497
19-4363
18-4575
17-4513
16-4471
15-4407
14-4390
13-4411
12-4457
11-4463
10-4471
9- 4414
8- 4508
7- 4452
6- 4441
5- 4489
4- 4410
3- 4454
2- 4479
1- 4423

AVG 4444
CHIR 0.95
KSTD 8895 (AVG * 16/8)

$\mu$ = average of the population
$\sigma$ = standard deviation of the population

The distribution from measurement samples of any process can be classified into expected shdpes that have been previously observed. Three are applicable to radioactive decay; Binominal, Poisson and Normal (also called Gaussian).

The Binominal distribution applies when the measured event can take one of two states. Tossing a coin is an obvious case. It can also be applied to a given atom either decaying or not in a time period. It is difficult to deal with computationally.

Since the number of atoms is very large and the expected probability of a decay occuring is very low (source life in years and measurement time in minutes), we can use the Poisson distribution which is a special case of the binominal distribution for these conditions. A special property of the Poisson distribution is that the expected standard deviation is equal to the square-root of the average value.

$$\boxed{\sigma=\sqrt{\bar{x}}}$$

If the sample is large enough we can approximate for the standard deviation of the sample.

$$\boxed{\delta=\sqrt{\mu}}$$

This is an important relationship. It means that if repeated measurements are taken without moving the gage and the detector electronics are working properly, then the spread of the counts will only be dependent upon the average count rate. This is in contrast to most measurements where the spread will depend upon the process. Fig A-3 shows the diameter of a part turned on a new lathe while fig A-4 shows the same part turned on an old lathe. Both lathes produce a part with the

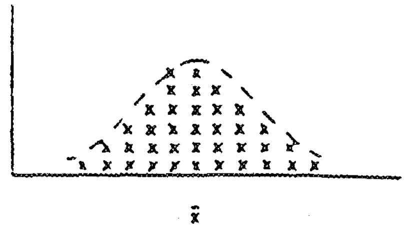


FIG A-2

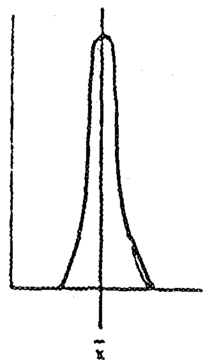


FIG A-3

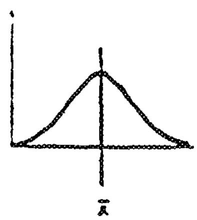


FIG A-4

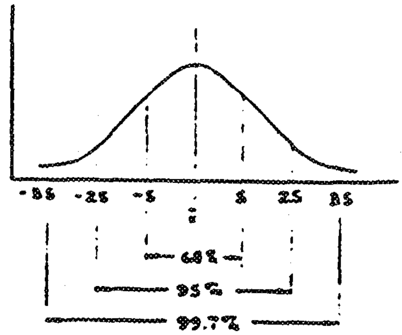


FIG A-5

same average diameter but a loose bearing caused the wider spread for parts manufactured on the older lathe.

›e Poisson distribution applies to discrete measurements e.g. count or no count. Provided the average value is large enough (20 or greater), the Poisson distributions can be approximated by the Normal distribution.

Using the Normal distribution simplifies things even further. It is a continuous distribution. It is symmetrical about the average, and most important it can be completely described by its average and standard deviation.

As shown in Fig A-5, for a Normal distribution, 68.3% of all counts will be within one standard deviation, 95.5% of all counts will be within two standard deviations, and 99.7% of all counts will be within three standard deviations.

Thus these three distribution models become identical for the case with a small individual success probability but with a large number of trials so that the expected average number of successes is large. This allows the use of the best features of each distribution for three statistical situations concerning the gage:

1) Single measurement precision
2) Expected spread of measurements
3) Expected difference between two measurements

.1 Single Measurement Precision

The expected variation for one standard deviation (68.3%) of a single count can be expressed as a percent error as follows;

$$\boxed{\%\,\text{ERROR} = 100\frac{\sqrt{x}}{x} = 100\frac{1}{\sqrt{x}}}$$

This expression reveals that the only way to improve the count precision (e.g. reduce the percent error) is to increase the size of x (e.g. the gage manufacture selects components for a higher count rate while the gage user counts for a longer period of time).

The following table demonstrates that a minimum of 10,000 counts is required to achieve a count precision of 1.0 percent or better 68.3% of the time.

| COUNTS | SR RT | COUNT PRECISION (68.3%) | COUNT PRECISION (95.5%) |
|---|---|---|---|
| 1 | 1 | 100.0 | |
| 10 | 3.16 | 31.6 | 63.2 |
| 100 | 10 | 10.0 | 20.0 |
| 1,000 | 31.62 | 3.16 | 6.32 |
| 10,000 | 100 | 1.00 | 2.0 |
| 100,000 | 316.22 | .32 | .63 |

The count precision improves with the square of the count. Thus taking four times the counts improves the count precision by a factor of two.

To provide a consistant frame of reference to the operator, the count displayed in the DR is always an equivalent 16 second count regardless of the time base selected. It is necessary to correct a precision determination for other time base selections as follows.

$$\boxed{\%\text{ERROR} = 100 \frac{1}{\sqrt{x \cdot t/16}}}$$

where t is the selected time in seconds

Example: A 64 second direct count is taken and displays 3000. The precision of the count is PCT=100/(SQR(3000*64/16) or 0.913%.

The direct reading is 2.0 gm/cm3. To determine the end measurement precision it is necessary to multiply the count precision by the slope of the calibration curve. Assuming a slope of 0.0416 gm/cm3 per percent, the 2.0 gm/cm3 reading varies by +/-0.038 gm/cm3 (68% of the time representing one standard deviation).

If you take repeat measurements but move the gage between reading then the standard deviation of that set of readings will include both the source random variation and the variation due to re-positioning the gage, and thus be larger.

## 1.2 Expected spread of measurements

An accepted quality control procedure for a random counting device is to record a series of 20 to 50 successive counts while keeping all conditions as constant as possible. By comparing the distribution of this sample of counts with the expected Normal distribution, abnormal amounts of fluction can be detected which could indicate malfunctioning of the gage.

The "Chi-squared test" is a quantitative means to make this comparsion. It can be used when a calculator is available to determine the standard deviation of the sample.

$$\chi^2 = \frac{(n-1)\ s2}{\sigma 2}$$

where $\chi 2$ is from the Chi-squared tables.

By substituting that the expected standard deviation is equal to the square-root of the average count ($\sigma = \sqrt{\bar{x}}$), re-arranging terms and taking the square-root of both sides:

$$\sqrt{\frac{x2}{(n-1)}} = \frac{s}{\sqrt{\bar{x}}}$$

Ideally the ratio on the right hand side of this expression should be 1.00. The degree to which this ratio departs from unity is an indicator of the extent to which the measured standard deviation differs from the expected standard deviation.

On the left hand side of the expression, the degree to which x2 differs from (n-1) is a corresponding allowance for the departure of the data from the predicted distribution (e.g. we flip a coin ten times and expect five heads and five tails but accept other distributions for a given sample). Chi-squared distribution tables are found in texts on statistics. The table values depend upon the degrees of freedom (one less than the number of counts) and the probability that a sample of counts would have a larger value of x2 than in the table. The x2 values for 2.5% and 97.5% (a 95% probability range) and 31 degrees of freedom are 17.54 and 48.23 Substituting these value into the left hand side of the expression gives ratio limits between 0.75 and 1.25 for 32 samples and a 95% probability.

If the ratio on the right side is between these limits then there is no reason to suspect the gage is not performing properly. If the ratio is outside these limits then the gage is suspect and further tests are in order (even a properly working gage will fall outside the Chi-squared limits 5% of the time).

If a calculator is not available which can easly determine the standard deviation, a qualitative method to compare the observed standard deviation with the expected standard deviation is to take a series of 10 counts and determine their mean and the square-root of their mean (guess the square-root to 2 digits if not available on the simple calculator). If their distribution is normal then 68.3% of the readings will be within the mean +/- the square-root of the mean (e.g. 7 out of 10).

EXAMPLE:

```
 9668
 9797 H
 9691
 9562 L
 9684
 9783 H
 9687
 9585
 9651
 9599
 -----
96707  TOTAL
```

This example has three counts outside the +/- square-root limits. Two are high and one is low. This is an acceptable distribution. There is no reason to suspect this gage.

$$\frac{96707}{10} = 9671 \text{ AVG}$$

SQ-RT = 98

AVG + SQ-RT = 9769
AVG - SQ-RT = 9573

Since this test only involves a sample of ten counts it is not very predictable. Even a properly operating gage will only pass this test one out of four times. If the test fails repeat it to see if any adverse trends exist.

1.3 Expected difference between two readings

The standard count or some other reference count should be recorded on a regular basis to allow observing if it stays the same or if any adverse trends are present. If enough counts have been used to determined the average and thus also the standard deviation of the population, then the Normal distribution may be used.

$$Z = \frac{\bar{x} - \mu}{\dfrac{\sigma}{\text{sq-rt}(n)}}$$

Expressing the $\bar{x}$ value in terms of the $\mu$ value plus a factor of the deviation.

$$\bar{x} = \mu +/- K * \sigma$$

$$Z = +/- K * \text{sq-rt}(n)$$

From the Normal tables, for 95% confidence, the Z value is 1.96.

$$K = +/- \frac{Z}{\sqrt{n}} = +/- \frac{1.96}{\sqrt{1}} = +/- 1.96$$

Thus the new reading should be equal to the average of the old reading plus/minus 1.96 times the square root of the old average.

This is true for the 16 second count which is direct. For another time case the K term must be reduced by the square-root of the count pre-scaling. e.g. for a 64 second count which is 4 times as long as the direct 16 second count the new reading should be plus/minus 0.98. A special case is the standard count which involves 32 each (n=32) 8 second counts. A new standard count should be equal to the old standard count plus/minus 0.49 times the square-root of the old standard count 95 percent of the time.

EXAMPLE:

The average of the daily standard count for the last month is 10,000. The square-root of this average is 100. A new standard count (32 each at 8 seconds but displayed as 16 seconds) should be between 9,951 and 10,041 (95% probability).

## 2.0 TROUBLE SHOOTING

| CONDITION | POSSIBLE CAUSE |
|---|---|
| Chi ratio too high, no change in the average count over previous. | Look for a drift in the counts over the measurement time. e.g. the average of the first five counts is significantly different than the average of the last five counts. |
| Chi ratio too low with an increase in the average count over previous. | Periodic noise occuring. Possibly an open filter capacitor in the HV power supply. |
| Chi ratio too low, no change in the average count. | Procedure error. Possibly analyzing normalized counts. The standard deviation must be determined on direct counts. |
| Chi ratio OK but change in average count. | Change in gage geometry. A change in counting efficiency will be normalized out by ratio technique. A change in gage geometry must either be corrected or the gage recalibrated. |

INTERFACING THE 503DR TO MICROCOMPUTER DEVICES

One of the features of the 503DR is to communicate with other computers as a remotely activated device or to download its logged data records to a disk or printer. There are two parts to this process; downloading software, and RS-232C serial communication hardware.

DOWNLOADING RECORDED DATA

Using the logging feature the gauge can record many records of site readings for recall later. It is extremely convenient if that data can be used in a program that can manipulate the data for the users needs. To get the data from the probe to the computer you may use the PRINT CD feature which stands for PRINT Computer Dump. Computer to computer communication requires a matched standard means of data communication implemented on both ends of the transfer. The gauge is capable of serial communication in an RS232 ASCII format which is standard for many computers and communication packages written to be used on them. One problem of serial communication is that it is not fool-proof and some form of error checking must be preformed on the data to insure that it is valid. The gauge uses a format where at the end of each line that is transmitted the computed checksum of the ASCII values of each character in the line is sent as the last data field. The receiving program must compare this value with the value it computes as the data is being received and send back an appropriate response. This format of communication is styled after ACK and NACK types of communication. The response is either ACK the line was received correctly and it is ACKnowledged or the response is NACK the line was not received correctly and it is Not ACKnowledged. The gauge receives the response and either transmits the line again or transmits the next line. The data records received are stored as a file on the current storage medium.

The program specifications that pertain to the gauge are:

RS232 type serial communication (TXD,RXD,GND).
1 start bit, 8 data bits, no parity, and 2 stop bits.
Baud rates; 110,300,1200,2400,4800,9600 (programs in basic may not operate at speeds higher than 300 baud).
ACK character ASCII value 6 decimal.
NACK character ASCII value 21 decimal (any unrecognized character is treated as a NACK character).
Checksum computed by ASCII values up to and including the comma before the checksum field.
'p' is the ASCII character (value 112 decimal) that will remotely activate the PRINT feature of the gauge.
CR is the ASCII character (value 13 decimal) that will remotely acknowledge the PRINT CD prompt.

Included here are the descriptions and program listings for several types of computers that compose a fairly good cross-section of the microcomputers that are currently available. Even if the computer that you are currently using does not directly correspond to one of the ones listed, there is a good chance that with the information provided in the listings and a careful study of the programmers manual for your computer that you could write a downloading program of your own. The last listing DRIN2DMP.BAS will convert the download file from the standard format to the format used by the IRRIGATION WATER MANAGEMENT system software from CPN CORP. It will operate as is on most of the microcomputers using variations of MIRCOSOFT BASIC for computers with disk drives.

ISTING #1

This version of DRDUMP will operate on most IBM pc's and their close compatibles. It has been used on an IBM PC, HEATH/ZENITH 100 or 150, TELEVIDEO 1605, and with the replacement of line number 310 with the one listed below it will also operate on the APPLE MACINTOSH with MICROSOFT BASIC.

```
310 OPEN "COM1:300,N,8,2" AS #1 ' Set port 300 baud, no parity,
        8 bits, 2 stop bits
```

The requirement for this program to work is the inclusion of the OPEN "COM1:... statement in the BASIC language used.

LISTING #2

This version of DRDUMP was written for a CP/M based microcomputer that uses the port method of I/O addressing. It was specifically written to operated on a VECTOR GRAPHICS Model 4 as is or the following computers with their associated line modifications.

VECTOR GRAPHICS 3

No changes just use the printer port.

VECTOR GRAPHICS VSX

```
160 ST% = 6 ' Status port number
360 OUT ST%,&H18 ' Reset the port
362 OUT ST%,&H14 ' set port mode; (1 start), 8 data, no parity,
        2 stop bits
364 OUT ST%,&H4C ' set port for transmit and receive
366 OUT ST%,&H15
368 OUT ST%,&HEA
370 OUT ST%,&H11
372 OUT ST%,&H00
374 OUT ST%,&H13
376 OUT ST%,&HC1
380 OUT ST%,&H10
830 OUT ST%,&H10: WHILE (INP(ST%) AND 4) = ZIP%: WEND ' Wait
        for transmitter ready
870 K% = 1000: OUT ST%,&H10: WHILE ((INP(ST%) AND ONE%)=ZIP%)
        AND (K% > ZIP%): K% = K% - ONE%: WEND
970 OUT ST%,&H10: WHILE (INP(ST%) AND 1) = ZIP%: WEND ' Wait
        for line feed character
```

OSM ZEUS

```
150 DP% = 2 ' data port number
160 ST% = 3 ' status port number
220 PRINT CHR$(26) ' Clear screen
360 OUT ST%,&H18 ' Reset the port
362 OUT ST%,&H14 ' set port mode; (1 start), 8 data, no
        parity, 2 stop bits
364 OUT ST%,&H4C ' set port for transmit and receive
366 OUT ST%,&H03
368 OUT ST%,&HE1
370 OUT ST%,&H05
372 OUT ST%,&HEA
374 OUT ST%,&H11
376 OUT ST%,&H00
378 OUT &H61,&H05 ' Set to 300 baud
380 OUT &H61,&H34
655 IF PRNTR% THEN LPRINT CHR$(26) ' Send to printer
830 OUT ST%,&H10: WHILE (INP(ST%) AND 4) = ZIP%: WEND ' Wait
        for transmitter ready
870 K% = 1000: OUT ST%,&H10: WHILE ((INP(ST%) AND ONE%)=ZIP%)
        AND (K% > ZIP%): K% = K% - ONE%: WEND
970 OUT ST%,&H10: WHILE (INP(ST%) AND 1) = ZIP%: WEND ' Wait
        for line feed character
1155 IF PRNTR% THEN LPRINT CHR$(26) ' Dump printer file
```

LISTING #3

This is an assembly language upgrade to listing #2 that will input data at speeds up to 9600 baud. The assembly language routine will have to be loaded at 40000 decimal before the basic program is run. The line changes required to implement it with listing #2 are:

```
DELETE 750-820
DELETE 900
DELETE 970-980

250 PRINT "Set DR baud rate to 9600."
383 OUT &H11,&H0D ' Set to 9600 baud
386 OUT &H11,&H00
520 WHILE NUMLIN% <= NLINES
845 BUF = 45055!
865 CALL 40000!
870 BUF = BUF + 1
890 CHAR = PEEK(BUF)
```

LISTING #4

The special characteristics of the OSBORNE 1 and it's memory-mapped I/O that is page flipped with the program memory spawned this interesting use of the CP/M I/O byte at location 3 to swap the console with the serial port to input the data as though it was keyboard entry. It requires the OSBORNE's SETUP program to set the configuration of the port to 300 baud before running the program.

LISTING #5 and #6

The APPLE II/II+/IIe/and IIc also have special considerations since in the beginning when the APPLE II was first designed there was no such thing as disk drives, serial communications, and printers available for microcomputers. The designers thought ahead enough to provide for 'plug-in' expansion that would include such things but INTEGER and APPLESOFT BASIC did not provide for direct interface with them. The result is a two part program in APPLESOFT BASIC and 6502 assembly language that receives the data through a SUPER SERIAL CARD (from APPLE) plugged in a card slot that is pointed to by the variable SLOT in the basic portion line 50.

Type in the BASIC listing #5 and save it as DRDUMP. Type in the HEXDUMP for listing #6 by using the following steps:

```
CALL -151
*300: A9 84 ...
 .
 .
*370: 20 9C FC 60
*BSAVE INPUTDR.AMP,A$300,L$74
```

LISTING #7

This program is simular to the others but uses the ROM routines built into the TRS80 MODEL III & 4 to input the data on the serial port. It will run on the MODEL III with no modifications and it will work on the MODEL 4 if it is brought up in MODEL III emulation mode (booted with a MODEL III disk).

LISTING #8

This is the file converter that manipulates the data into the format expected by the IRRIGATION WATER MANAGEMENT program from CPN CORP. It will operate on most computers that use MICROSOFT BASIC for disk drives.

## ;-232C SERIAL COMMUNICATION HARDWARE

ıe 503DR uses the RS-232C industry standard serial communication hod. The 503DR cable connector is a special CPN CORP. configuration nat can be linked to a 25 pin D-type connector on the opposite end of he cable. Most computers will have the $DP25_S$ (25 pin D-type sockets) onnector built in although the IBM asynchronous communications card and few others have a DP25P (25 pin D-type pins) connector built in.

ere are a collection of some of the more popular cable configurations:

LISTING #1

```
10 '   DRDUMP.BAS  2/15/85 for IBM type system.
20 ON ERROR GOTO 1000
30 '
40 '********INITIALIZATION********
50 '
60  BKSP$=CHR$(29)
70  K%=1000
80  ANSWER$=" yesYES"
90  ACK%=6
100  NAK%=21
110  CR%=13
120  FF$=CHR$(12)
130  BK%=0
140 '
150 '****  PROCEDURE  ****
160 '
170  OPEN "O",3,"DRIN.DAT":'  open output data file
180  PRINT FF$
190  PRINT TAB(30)"DRDUMP upload probe data": PRINT:PRINT
200  PRINT "Set DR baud rate to 300bps."
210  PRINT "Connect cable to DR."
220  INPUT "Enter the date (mm/dd)";DATE1$
230  PRINT #3,DATE1$
240  PRINT "Do you want a hard copy of probe data  Y";STRING$(3,BKSP$);: INPUT ANS$ ' PRINT OUT OF PROBE DATA
250  IF INSTR(ANSWER$,ANS$)<>0 THEN PRNTR%=-1 ELSE PRNTR%=0 'SET PRINTER FLAG BASED ON ANSWER
260  IF PRNTR% THEN LPRINT TAB(45);"PROBE DATA FROM ";DATE1$:LPRINT:LPRINT
270  PRINT:PRINT:PRINT"PROBE DATA";TAB(60);"CHECKSUM";TAB(70);"RESPONSE"
280  PRINT STRING$(78,"=")
290  IF PRNTR% THEN LPRINT"PROBE DATA";TAB(60);"CHECKSUM";TAB(70);"RESPONSE"
300  IF PRNTR% THEN LPRINT STRING$(78,"=")
310  OPEN "COM1:300,N,8,2,CS,DS,CD" AS #1:' set port 300 baud, no parity, 8 bits, 2 stop bits
320 ' Remotely activate PRINT CD on DR.
330  PRINT #1,"p": FOR I = 1 TO 1000: NEXT: PRINT #1,"c"
340  FOR I = 1 TO 1000: NEXT: PRINT #1,CHR$(CR%): FOR I = 1 TO 1000: NEXT: RESP%=CR%
350  IF LOC(1) <> 0 THEN JUNK$=INPUT$(1,1) ' Get garbage from serial port.
360  GOSUB 680 '  call first line in
370  GOSUB 950 ' PRINT TLINE
380 '
390  NLINES%=VAL(TLINE$): '  parse # of transmitted lines
400  PRINT #3,TLINE$: '  put header line in output file
410 '
420 '---- INPUT DATA TO "DRIN.DAT" ----
430  K%=100: NUMLIN%=0 'Set K% for first pass and initialize NUMLIN%
440  WHILE (K%<>0) AND (NOT BK%) ' Loop as long as there is no error or the timer doesn't time out
450    NUMLIN%=NUMLIN%+1
460    GOSUB 680 '  get records from DR and put in file DRIN.DAT
470    IF (K%=0) OR BK% THEN 510 ' Skip to exit if time is out or error
480    PRINT #3,TLINE$
490    IF NUMLIN% > NLINES%-1 THEN TLINE$ = TLINE$ + "**EXTRA DATA LINE**" ' Mark data that exceeds original number of lines
500    GOSUB 950 ' PRINT TLINE
510  WEND
520 '
530  PRINT #1,CHR$(ACK%);
540 '
550 '----  QUIT  ----
```

```
0  IF PRNTR% THEN LPRINT FF$ ' Output a formfeed
   CLOSE #1
.  CLOSE #3
0  PRINT "Is this data satisfactory  Y";STRING$(3,BKSP$);:INPUT ANS$: IF INSTR(ANSWER$,ANS$) = 0 THEN RUN 'ASK FOR USER 'OK

0  IF BK% THEN END ' Finish if error has occured
0  CHAIN "DRIN2DMP.BAS",ALL ' CONVERT DATA STRING TO PARSED INFORAMTION.
)  END
) '
) '######SUBROUTINES######
0 '
) 'SUB-----  INPUT LINE  -----
) '
)  PRINT #1,CHR$(RESP%);
)  TLINE$=""
)  CKSUM%=0 '    reset cksum for new record
)  K%=1000: WHILE (LOC(1)=0) AND (K%>0): K%=K%-1:WEND
)   IF K% = 0 THEN RETURN
)   CHAR$=INPUT$(1,#1)
)   IF ASC(CHAR$)=13 THEN GOTO 810 '  is it the END OF RECORD?
)   IF INKEY$ <> "" THEN ERROR
)   TLINE$=TLINE$+CHAR$ '  if not, add it to the record string
)   NUMB%=ASC(CHAR$)
)   CKSUM%=CKSUM%+NUMB% '  and record it in the cksum
)  GOTO 710 '   get next character
 '
     END OF RECORD processing
     IF LOC(1)=0 THEN 820 ' WAIT FOR A CHARACTER IN COM-BUFFER
     CHAR$=INPUT$(1,#1) ' DISCARD LINE FEED
     LASTCHAR%=LEN(TLINE$) '  length of data string
     LSTCOMMA%=LASTCHAR% '  initialize comma pointer
     COMCHAR$=MID$(TLINE$,LSTCOMMA%,1)
     WHILE COMCHAR$<>","
       CKSUM%=CKSUM%-ASC(COMCHAR$)
       LSTCOMMA%=LSTCOMMA%-1 '  remove checksum chars from cksum and find
       COMCHAR$=MID$(TLINE$,LSTCOMMA%,1) '  the transmitted checksum field
     WEND
     IF CKSUM%=VAL(RIGHT$(TLINE$,LASTCHAR%-LSTCOMMA%)) THEN RESP%=ACK%:DISPLAY$=" OK" ELSE RESP%=NAK%:DISPLAY$=" REPT":GOTO
)0 ' repeat line till right
   RETURN
 '
 ' PRINT TLINE
 '
 PRINT TLINE$;TAB(60);CKSUM%;TAB(70);RESP%;DISPLAY$ ' DISPLAY DATA
 IF PRNTR% THEN LPRINT TLINE$;TAB(60);CKSUM%;TAB(70);RESP%;DISPLAY$ ' PRINT DATA
 RETURN
0  PRINT "COMMUNICATION INTERUPTED": BK%=-1: RETURN ' HANDLE ERROR INCLUDING KEYBOARD INTERUPTIONS
```

LISTING #2

```
10 ' DRDUMP.BAS  2/15/85 FOR VECTOR 4 TYPE SYSTEMS.
20  ON ERROR GOTO 1170
30 '   TRANSFER FROM PROBE TO FILE DRIN.DAT
40 '
50 '%%%%%%%%INITIALIZATION%%%%%%%%
60  K%=1000
70  ANSWER$ = " yesYES"
80  BKSP$ = CHR$(23)
90  ACK% = 6
100  NAK% = 21
110  CR = 13
120  ONE% = 1
130  TWO% = 2
140  ZIP% = 0 '  numerical constants
150  DP% = 4:' data port number
160  ST% = 5:' status port number
170  BK% = 0
180 '
190 '%%%%  PROCEDURE  %%%%
200 '
210  OPEN "O",3, "DRIN.DAT":'  open output data file
220  PRINT CHR$(4):' clear screen
230  PRINT TAB(30)"DRDUMP upload probe data"
240  PRINT: PRINT: PRINT
250  PRINT "Set DR baud rate to 300."
260  PRINT "Connect cable to DR."
270  INPUT "Enter the date (mm/dd)";DATE1$
280  PRINT #3,DATE1$
290  PRINT "Do you want a hard copy of probe data  Y";STRING$(3,BKSP$);: INPUT ANS$ 'PRINT OUT OF PROBE DATA
300  IF INSTR(ANSWER$,ANS$)<> 0 THEN PRNTR%=-1 ELSE PRNTR%=0 ' Set printer flag based on answer.
310  IF PRNTR% THEN LPRINT TAB(45);"PROBE DATA FROM ";DATE1$: LPRINT:LPRINT
320  PRINT:PRINT:PRINT"PROBE DATA";TAB(60);"CHECKSUM";TAB(70);"RESPONSE"
330  PRINT STRING$(78,"=")
340  IF PRNTR% THEN LPRINT"PROBE DATA";TAB(60);"CHECKSUM";TAB(70);"RESPONSE"
350  IF PRNTR% THEN LPRINT STRING$(78,"=")
360  OUT ST%,&H40: '  reset the port
370  OUT ST%,&HCE: '  set port mode;  (1 start), 8 data,no parity, 2 stop bits
380  OUT ST%,&H25: '  set port for transmit and receive
390 ' Remotely turnon the PRINT CD for data dump.
400  OUT DP%,ASC("c"):FOR I = 1 TO 1000: NEXT: OUT DP%,ASC("c")
410  FOR I = 1 TO 1000: NEXT: OUT DP%,CR:FOR I = 1 TO 1000: NEXT: OUT DP%,CR
420 '
430 '  Input header line
440  GOSUB 850 '  call first line in
450  GOSUB 1120 ' PRINT TLINE
460 '
470  NLINES = VAL(TLINE$)  '  parse # of transmitted lines
480  PRINT #3,TLINE$  '  put header line in output file
490 '
500 '----  Input data to "DRIN.DAT"  ----
```

```
510  K% = 100: NUMLIN% = 0 ' Set K% for first pass and initialize NUMLIN%
520  WHILE (K% <> 0) AND (NOT BK%) ' Loop as long as there is no error or the timer doesn't time out
      NUMLIN% = NUMLIN% + 1
540   GOSUB 830 '  get all the records from the DR and put them in the file DRIN.DAT
550   IF (K% = 0) OR BK% THEN 590 ' Skip to exit loop if time is out or error
560   PRINT #3, TLINE$
570   IF NUMLIN% > NLINES-1 THEN TLINE$ = TLINE$ + "**EXTRA DATA LINE**" ' Mark data that exceeds original number of lines
580   GOSUB 1120 ' PRINT TLINE
590  WEND
600 '
610  OUT DP%, ACK%:'    Do one more ACK to allow DR to finish
620 '
630 '
640 '-----  QUIT  ----
650  IF PRNTR% THEN LPRINT FF$ ' Output a formfeed
660  CLOSE #3
670  PRINT"Is this data satisfactory  Y";STRING$(3,BKSP$);:INPUT ANS$:IF INSTR(ANSWER$,ANS$) = 0 THEN 10: ' ASK USER FOR 'OK'
680  IF BK% THEN 700 ' Skip converting data if error has occured
690  CHAIN "DRIN2DMP.BAS", ALL ' Convert data string to parsed information.
700  END
710 '
720 '******SUBROUTINES******
730 '
740 '  SUB ---  Input first line  -----
750 ' LINES 860 THRU 920 HAVE TIME CRITICAL CODE.
760 ' LINE 860=> WAIT FOR CHARACTER TO BE RECEIVED (TIME WAIT)
770 ' LINE 870=> CHECK FOR OVER-RUN STATUS
    ' LINE 880=> GET CHARATER
790 ' LINE 890=> RETURN IF TIMER RAN OUT
800 ' LINE 900=> IS IT "CR" THEN END OF RECORD
810 ' LINE 910=> CHECK FOR KEYBOARD INTERUPTION
820 ' LINE 920=> MAKE TLINE$, AND CHECKSUM. GO GET NEXT CHARACTER
830  WHILE (INP(ST%) AND 1) = ZIP%: WEND '   Wait for transmitter ready
840  OUT DP%,RESP% '  Send response to DR
850  TLINE$ = "" '    Clear line record buffer
860  CKSUM% = ZIP% '   Reset checksum for new record
870  K% = 1000: WHILE ((INP(ST%) AND TWO%)=ZIP%) AND (K% > ZIP%): K% = K% - ONE%: WEND
880  IF (INP(ST%) AND 16)<> ZIP% THEN OUT ST%,&H35: PRINT "** O-R **"
890  CHAR = INP(DP%)
900  IF K% = 0 THEN RETURN
910  IF CHAR = CR THEN 970
920  IF INKEY$ <> "" THEN ERROR
930  TLINE$ = TLINE$ + CHR$(CHAR): CKSUM% = CKSUM% + CHAR: GOTO 870
940 '
950 '  END OF RECORD processing
960 '
970    WHILE (INP(ST%) AND 2)=ZIP%: WEND '  wait for line feed char
980    CHAR = INP(DP%): '  get the line feed
990    LASTCHAR = LEN(TLINE$): '  get length of data string
1000    LSTCOMMA = LASTCHAR: '  initialize comma pointer
1010    COM$= MID$(TLINE$,LSTCOMMA,ONE%)
```

```
1020    WHILE COM$ <> ","
1030      CKSUM% = CKSUM% - ASC(COM$)
1040      LSTCOMMA = LSTCOMMA - ONE%: '   remove checksum chars from cksum and find
1050      COM$ = MID$(TLINE$,LSTCOMMA,ONE%): '  the transmitted checksum field
1060    WEND
1070 '
1080 ' Response is ACK if checksum is correct, else NAK and repeat until we get it right
1090    IF CKSUM%=VAL(RIGHT$(TLINE$,LASTCHAR-LSTCOMMA)) THEN RESP%=ACK%: DISPLAY$ = " ACK": ELSE RESP%=NAK%:DISPLAY$ = " NAK
: GOSUB 1120: GOTO 740
1100  RETURN
1110 '
1120 ' PRINT TLINE
1130 '
1140 PRINT TLINE$;TAB(60);CKSUM%;TAB(70);RESP%;DISPLAY$ ' DISPLAY DATA
1150 IF PRNTR% THEN LPRINT TLINE$;TAB(60);CKSUM%;TAB(70);RESP%;DISPLAY$ ' PRINT DATA
1160 RETURN
1170 PRINT ERR,ERL:PRINT "COMMUNICATION INTERUPTED": BK% = -1: RETURN ' HANDLE ERROR INCLUDING KEYBOARD INTERUPTIONS
```

**LISTING #3**

```
TYPE DRLIN.ASM
***** PGM: DRLIN.ASM ********* 850304 ********
;
;ASY SUBROUTINE FOR DATA INPUT FROM DR
;PGM START AT 40000D, 9C40H
;DATA STORAGE START AT 45056D, B000H
;-------------------------------------------------
;
        ORG     40000D  ; Addr for call from BASIC program
        PUSH    PSW     ;
        PUSH    H       ;
        LXI     H,0B000H; String pointer
                        ;
BEGIN   IN      005     ; Wait for character
        ANI     002     ;
        JZ      BEGIN   ;
        IN      004     ; Input character
        MOV     M,A     ; Store it
        INX     H       ; Move store pointer
        CPI     0AH     ; Is it a linefeed
        JNZ     BEGIN   ; No, get another character
                        ;
        POP     H       ;
        POP     PSW     ;
        RET             ;
```

LISTING #4

```
10 ' 503DR  TO OSBORNE UPLOADER 2/15/85
   ON ERROR GOTO 900
30 IOPORT%=3
40 IONORM%=PEEK(IOPORT%)
50 IOCOMM%=&H41
60 ACK$=CHR$(6)
70 NACK$=CHR$(21)
80 CR$=CHR$(13)
90 BKSP$=CHR$(8)
100 ANSWER$=" yesYES"
110 ZIP%=0:ONE%=1:TWO%=2
120 BK%=0: ERRFLAG% = 0
130 '
140 ' SETUP PORT AND PROMPT USER
150 '
160 OPEN "O",3,"DRIN.DAT" ' OPEN OUTPUT DATA FILE
170 PRINT CHR$(26) ' CLEAR THE SCREEN
180 PRINT TAB(15)"DRDUMP upload probe data":PRINT:PRINT
190 PRINT "Set DR baud rate to 300bps."
200 PRINT "Connect the cable to the DR."
210 INPUT "Enter the date mm/dd";DATE1$
220 PRINT #3,DATE1$
230 PRINT:PRINT
240 PRINT "PROBE DATA";TAB(45);"RESPONSE"
250 PRINT STRING$(52,"-")
260 ' Remotely activate PRINT CD on DR.
    POKE IOPORT%,IOCOMM%: PRINT "p":FOR X = 1 TO 1000: NEXT: PRINT "p"
280 FOR X = 1 TO 1000: NEXT: PRINT CR$: FOR X = 1 TO 1000: NEXT: RESP$ = CR$
290 JUNK$=INKEY$ ' Collect garbage off serial port.
300 '
310 ' ------ INPUT DATA TO "DRIN.DAT" ------
320 '
330 WHILE BK% = 0 ' GET RECORDS TILL TIMEOUT
340   GOSUB 540 ' GET ALL THE RECORDS FROM THE DR AND PUT THEM IN THE FILE DRIN.DAT
350   IF BK% = 1 THEN 380 ' CHECK FOR TIMEOUT
360   PRINT #3,TLINE$
370   GOSUB 830 ' PRINT TLINE
380 WEND
390 '
400 POKE IOPORT%,IOCOMM%:PRINT ACK$:POKE IOPORT%,IONORM% ' DO ONE MORE ACK TO ALLOW DR TO FINISH
410 '
420 '
430 ' ------ QUIT ------
440 CLOSE #3
450 PRINT "Is this data satisfactory  Y";STRING$(3,BKSP$);:INPUT ANS$:IF INSTR(ANSWER$,ANS$) = 0 THEN RUN ' ASK FOR USER 'OK'
460 IF ERRFLAG% THEN END
470 CHAIN "DRIN2DMP.BAS",ALL ' CONVERT DATA STRING TO PARSED INFORMATION.
480 END
490 '
500 ' ------ INPUT SUBROUTINES -----
```

## LISTING #5

```
0  REM      DRDUMP 3/6/85          FOR APPLE II
   W/ SUPER SERIAL CARD               NO 80-COL CARDS
:0  REM
:0  REM  INITIALIZATION
0  REM
5 RS = 6: REM   SET RESPONSE DEFAULT
6  DIM TL$(279): REM   MAX # OF RECORDS 279
0 SLOT = 3: REM  SLOT # OF SSC
0 DK$ =  CHR$ (4): REM  DISK COMMAND
5  GOSUB 1000
0 CM$ =  CHR$ (1): REM  SSC COMMAND
0  PRINT DK$;"PR#";SLOT: REM  ACCESS SERIAL CARD
0  PRINT CM$;"6 BAUD": REM  SET BAUD RATE TO 300 BPS
00  PRINT CM$;"4 DATA": REM  8 DATA BITS, 2 STOP BITS
10  PRINT CM$;"0 PARITY": REM  NO PARITY
20  PRINT CM$;"LF DISABLE": REM  NO AUTO LINE FEEDS
21  PRINT CM$"ECHO ENABLE": REM  PRINT TO SCREEN
22  PRINT CM$"MASK ENABLE": REM  MASK OUT IN COMING LINEFEEDS
25  PRINT CM$"ZAP": REM  DISABLE COMMAND CHARACTERS
30  PRINT DK$;"PR#0": REM  RESET TO SCREEN
40  REM
50  REM     PUT UP HEADERS
60  REM
70  HOME
30  HTAB 7: PRINT "DRDUMP UPLOAD PROBE DATA"
70  PRINT : PRINT
00  PRINT "SET DR BAUD RATE TO 300 BPS."
10  PRINT "CONNECT THE CABLE TO DR."
20  INPUT "ENTER DATE => ";DT$
30  PRINT : PRINT "DATA";: HTAB 32: PRINT "RESPONSE": PRINT
------------------------------------------------------------------------"
10  POKE 34,9: REM    SET SCROLLING WINDOW
97  REM
98  REM  START DUMPING DATA
99  REM
00  PRINT DK$"PR#";SLOT: PRINT DK$"IN#";SLOT
04  REM  TURN ON PRINT CD REMOTELY
05  PRINT  CHR$ (112);: FOR X = 1 TO 1000: NEXT : PRINT  CHR$
12);: FOR X = 1 TO 1000: NEXT : PRINT  CHR$ (13);: FOR X =
TO 1000: NEXT : PRINT  CHR$ (13);: FOR X = 1 TO 300: NEXT

06 L = 0: &  INPUT TL$(L): GOSUB 1500: IF RS = 21 THEN  PRINT
HR$ (RS);: GOTO 506: REM  GET FIRST LINE
07  FOR L = 1 TO  VAL (TL$(0)) - 1
08  PRINT  CHR$ (RS);: REM  SEND RESPONSE
0  &  INPUT TL$(L): REM  GET DATA FROM PROBE
20  GOSUB 1500: REM  COMPUTE CHECKSUM & RESPONSE
25  IF RS = 21 THEN 508: REM  IF NAK GET AGAIN
35  NEXT
36  PRINT  CHR$ (6): REM  TURN OFF PROBE
37  PRINT DK$"PR#0": PRINT DK$"IN#0": REM  RETURN APPLE TO
ORMAL
39  GOSUB 5000: REM  WRITE DATA TO DISK
0  TEXT : END
7  REM
```

```
000  REM
1000  PRINT DK$"BLOAD INPUTDR.AMP": REM  GET AMPERSAND ROUTINE
TO INPUT SERIAL DATA
1010  PRINT DK$"BLOAD INPUTDR.AMP"
1040  POKE 1013,76: POKE 1014,0: POKE 1015,3: REM   POINT &
 CTOR TO PAGE $300(768 DECIMAL)
1050  RETURN
1497  REM
1498  REM  COMPUTE CHECKSUM & DETERMINE RESPONSE
1499  REM
1500 CK = 0: FOR X = 1 TO  LEN (TL$(L)):CK = CK +  ASC ( MID$
(TL$(L),X,1)): NEXT
1509  REM  LOOK FOR LAST COMMA
1510  FOR LK =  LEN (TL$(L)) TO 0 STEP  - 1
1520  IF  MID$ (TL$(L),LK,1) = "," THEN CS =  VAL ( RIGHT$ (TL$(L),
LEN (TL$(L)) - LK)):LK = 0: GOTO 1550
1530 CK = CK -  ASC ( MID$ (TL$(L),LK,1))
1550  NEXT
1559  REM  IF CHECKSUMS MATCH SEND AN ACK
1560  IF CK = CS THEN RS = 6: GOSUB 2000
1569  REM  IF CHECKSUMS DON'T MATCH SEND A NAK
1570  IF CK <  > CS THEN RS = 21: GOSUB 2100
1580  RETURN
1997  REM
1998  REM  SEND ACK TO SCREEN
1999  REM
2000 CH =  PEEK (40) +  PEEK (41) * 256
2010 CH = CH + 37
2011  POKE CH, ASC ("A") + 128
2012  POKE CH + 1, ASC ("C") + 128
2013  POKE CH + 2, ASC ("K") + 128
2020  CALL  - 926
2030  RETURN
2097  REM
2098  REM  SEND NAK TO SCREEN
2099  REM
2100 CH =  PEEK (40) +  PEEK (41) * 256
2110 CH = CH + 37
2111  POKE CH, ASC ("N") + 128
2112  POKE CH + 1, ASC ("A") + 128
2113  POKE CH + 2, ASC ("K") + 128
2120  CALL  - 926
2130  RETURN
4997  REM
4998  REM  WRITE DATA TO DISK FILE DUMP.DATA
4999  REM
5000  PRINT "WRITING DATA TO DISK..."
5005  PRINT DK$"OPEN DUMP.DATA"
5010  PRINT DK$"WRITE DUMP.DATA"
5015  PRINT DT$
5020  FOR X = 0 TO  VAL (TL$(0)) - 1: PRINT TL$(X): NEXT
5030  PRINT DK$"CLOSE"
5040  RETURN
```

LISTING #6

```
                **********************************
                *                                *
                *       INPUTDR.AMP 3/7/85       *
                *                                *
                *       WORKS WITH APPLE II'S    *
                *       THAT HAVE A SUPER-SERIAL *
                *       CARD AND IN THE 40 COL   *
                *       MODE ONLY.               *
                *                                *
                *       BY RANDY ANGLE FOR       *
                *       CPN CORP.                *
                *                                *
                **********************************

                IN      =       $0200
                GDBUFS  =       $D539
                SYNCHR  =       $DEC0
                PTRGET  =       $DFE3
                GETSPA  =       $E452
                MOVSTR  =       $E5E2
                CLREOL  =       $FC9C
                RDCHAR  =       $FD35
                COUT1   =       $FDF0
                BELL    =       $FF3A
                LENINS  =       $FD
                FRETOP  =       $6F
                VARPNT  =       $83
                INPTOK  =       $84
                INVFLG  =       $32


                        ORG     $0300

00: A9 84                       LDA     #INPTOK
02: 20 C0 DE                    JSR     SYNCHR
05: 20 E3 DF                    JSR     PTRGET
08: A2 00                       LDX     #$00
0A: 20 5A 03                    JSR     NXTCHAR
0D: 86 FD                       STX     LENINS
0F: 20 39 D5                    JSR     GDBUFS
12: A5 FD                       LDA     LENINS
14: 20 52 E4                    JSR     GETSPA
17: A2 00                       LDX     #$00
19: A0 02                       LDY     #$02
1B: 20 E2 E5                    JSR     MOVSTR
1E: A0 00                       LDY     #$00
20: A5 FD                       LDA     LENINS
22: 91 83                       STA     (VARPNT),Y
24: C8                          INY
25: A5 6F                       LDA     FRETOP
27: 91 83                       STA     (VARPNT),Y
29: C8                          INY
2A: A5 70                       LDA     FRETOP+1
2C: 91 83                       STA     (VARPNT),Y
2E: 60                          RTS
2F: A5 32       NOTCR           LDA     INVFLG
31: 48                          PHA
32: A9 FF                       LDA     #$FF
34: 85 32                       STA     INVFLG
```

```
[illegible]
20 '
30 ' INITIALIZATION
40 '
50 DEFINT A-Z
60 CLEAR 10000
70 TM = 500: NU = 0
80 ACK = 6:  NAK = 21: CR = 13: N0 = 0: N1 = 1: N2 = 2
90 CI = 16872: CO = 16880
100 '
110 ' SET UP SCREEN AND SET COMMUNICATION MODES
120 '
130 CLS
140 PRINT TAB(20),"DRDUMP FROM HYDROPROBE": PRINT: PRINT
150 PRINT "CONNECT CABLE TO DR"
160 PRINT "SET DR TO 300 BAUD"
170 INPUT "ENTER THE DATE";DATE1$
180 INPUT "DO YOU WANT A HARDCOPY";ANS$
190 IF ANS$ = "Y" OR ANS$ = "y" THEN PRNT = (1=1)
200 PRINT: PRINT "DATA";TAB(58)"RESPONSE"
210 PRINT STRING$(65,"-")
220 IF PRNT THEN LPRINT TAB(25)"PROBE DATA FROM ";DATE1$
    IF PRNT THEN LPRINT "DATA";TAB(58)"RESPONSE"
    IF PRNT THEN LPRINT STRING$(65,"-")
250 OPEN "O",#3,"DRIN.DAT"
260 PRINT #3,DATE1$
270 POKE 16889,119 ' 8 DATA 2 STOP NO PARITY
280 POKE 16888,(16*5)+5 ' 300 BAUD
290 POKE 16890,0 ' DON'T WAIT
300 DEFUSR0 = &H5A: X = USR(0)
310 DEFUSR1 = &H50: DEFUSR2 = &H55
320 '
330 ' TURN ON DUMP REMOTELY
340 '
350 POKE CO,ASC("p"):X = USR2(0):FOR X = 1 TO 1000:NEXT:POKE CO,ASC("p"):FOR X = 1 TO 1000:NEXT
360 POKE CO,CR:X =USR2(0):FOR X = 1 TO 1000:NEXT:R = CR
370 '
380 ' GET THE FIRST LINE OF DATA
390 '
400 GOSUB 660
410 GOSUB 920
420 PRINT #3,TL$
430 CT = VAL(TL$)
440 '
450 ' GET THE REST OF THE DATA
460 '
470 FOR CD = CT-1 TO 1 STEP -1
        GOSUB 660
        GOSUB 920
500     PRINT #3,TL$
```

```
510 NEXT
520 POKE CO,ACK
530 X = USR2(0)
540 '
550 ' CLOSE FILES AND QUIT
560 '
570 CLOSE #3
580 IF PRNT THEN LPRINT CHR$(12)
590 PRINT "IS THIS DATA SATISFACTORY";
600 ANS$ = INKEY$: IF ANS$ = "" THEN 600 ELSE PRINT ANS$
610 IF ANS$ <> "Y" AND ANS$ <> "y" THEN 10
620 END
630 '
640 ' DOWNLOAD DATA RECORD ONE LINE AT A TIME
650 '
660 POKE CO,R
670 X = USR2(0)
680 TL$ = ""
690 NU = 0
700 CK = NO
710 X = USR1(0): CN = PEEK(CI)
720 IF CN = 0 THEN NU = NU + 1
730 IF NU > TN THEN NU = 0: R = NAK: GOSUB 920: GOTO 660
740 IF CN = 0 GOTO 710
750 IF CN = CR GOTO 820
760 TL$ = TL$ + CHR$(CN)
770 CK = CK + CN
780 GOTO 710
790 '
800 ' COMPUTE CHECKSUM FIND RESPONSE
810 '
820 X = USR1(0): CN = PEEK(CI): IF CN = 0 GOTO 820
830 LC = LEN(TL$)
840 CP = LC
850 CN$ = MID$(TL$,CP,N1)
860 IF CN$ <> "," THEN CK = CK - ASC(CN$): CP = CP - 1: GOTO 850
870 IF CK = VAL(RIGHT$(TL$,LC-CP)) THEN R = ACK ELSE R = NAK: GOTO 660
880 RETURN
890 '
900 ' PRINT DATA RECORD
910 '
920 PRINT TL$; TAB(63);:IF R = ACK THEN PRINT "ACK" ELSE PRINT "NAK"
930 IF PRNT THEN LPRINT TL$;TAB(63);:IF R = ACK THEN LPRINT "ACK" ELSE LPRINT "NAK"
940 RETURN
```

DRIN2DMP.BAS 3/11/85

LISTING #8

```
DIM KD%(100),DP(100)
 '* PROCEDURE ****
  CONVERT DRIN.DAT TO DRDUMP.DAT

OPEN "I",3,"DRIN.DAT" '  open probe info file
INPUT #3,DATE1$
INPUT #3,NR,CD$,SN,UN$,STC,KDATA%,DEPTHS%,CKSUM% ' get header info
 DASH%=INSTR(CD$,"-") ' FIND VERSION
 IF DASH% = 0 THEN LNS% = (1=1) ELSE LNS% = (1=2) ' SET LINES NUMBERS FLAG FOR INPUT
 IF LNS% THEN NUMCALS% = 9 ELSE NUMCALS%  = 17 ' SET NUMBER OF CALIBRATIONS,
 FOR I%=2 TO NUMCALS%
   IF LNS% THEN INPUT #3,CAL%,SL,YINT,CKSUM% ELSE INPUT #3,LN%,CAL%,SL,YINT,CKSUM% '  get all the calibration info
 NEXT
 OPEN "O",2,"DRDUMP.DAT" '  open the output file
 PRINT #2,DATE1$
 PRINT #2,DEPTHS%","KDATA%-1 '  write # of data records, # of depths per record
 WHILE NOT EOF(3) '  transfer info
   IF LNS% THEN INPUT #3,ID%,CAL% ELSE INPUT #3,LN%,ID%,CAL%
   FOR I%=KDATA% TO 1 STEP -1
     INPUT #3,KD%(I%) '  get all key fields
   NEXT
   FOR I%=DEPTHS% TO 1 STEP -1
     INPUT #3,DP(I%) '  get the depth readings
   NEXT
   INPUT #3,CKSUM% '  get the checksum
   FARM%=INT(ID%/100) '  parse the farm #
   FLD%=ID%-(100*FARM%) '  parse the field #
   SITE%=KD%(KDATA%) '  get the site #
   PRINT #2,FARM%;",";FLD%;",";SITE%;",";  '  output farm,field,site info
   FOR I%=1 TO KDATA%-1
     PRINT #2,KD%(I%)",";
   NEXT
   FOR I%=1 TO DEPTHS%
     PRINT #2,DP(I%);",";  '  output depth readings
   NEXT
   PRINT #2,CKSUM% '  output checksum (end of record)
 WEND
 CLOSE
 RUN "DRWORK1" ' OR RUN WHATEVER PROGRAM YOU WISH
END
```

```
**********************************************************************
CABLE, GENERAL PURPOSE
DR503 conn.                    CABLE            RS232 conn.  DP25S
--------------------------    -------------    ----------------------------
                                                1      PROTECTIVE GROUND

SERIAL INPUT          4   <-----BLU-----        2      TXD
SERIAL OUTPUT         3    -----GRN------>      3      RXD

ENABLE                7   <-----YEL-----        4      REQUEST TO SEND

+10 V                 1    -----OR--+---->      5      CLEAR TO SEND
                                    |---->      6      DATA SET READY

GROUND                2   <-----BLK------>      7      GROUND
**********************************************************************
```

```
**********************************************************************
CABLE, GENERAL PURPOSE
DR503 conn.                    CABLE            RS232 conn.  DP25P
--------------------------    -------------    ----------------------------
                                                1      PROTECTIVE GROUND

SERIAL INPUT          4   <-----BLU-----        2      TXD
SERIAL OUTPUT         3    -----GRN------>      3      RXD

ENABLE                7   <-----YEL-----        4      REQUEST TO SEND

+10 V                 1    -----OR--+---->      5      CLEAR TO SEND
                                    |---->      6      DATA SET READY

GROUND                2   <-----BLK------>      7      GROUND
**********************************************************************
```

```
**********************************************************************
CABLE, VECTOR GRAPHICS 4, J1 MODEM CONNECTOR, 300 BAUD
DR503 conn.                    CABLE            RS232 conn.  DP25P
--------------------------    -------------    ----------------------------
                                                1      PROTECTIVE GROUND

SERIAL INPUT          4   <-----BLU-----        2      TXD
SERIAL OUTPUT         3    -----GRN------>      3      RXD

                                 NC <---        4      REQUEST TO SEND

+10 V                 1    -----OR--+---->      5      CLEAR TO SEND
                                    |---->      6      DATA SET READY

GROUND                2   <-----BLK------>      7      GROUND

                                 NC <---       20      DATA TERMINAL READY

ENABLE                7    -----YEL  NC
**********************************************************************
```

```
*******************************************************************************
  BLE, VECTOR GRAPHICS 3, J2 PRINTER CONNECTOR, 300 BAUD
..503 conn.                     CABLE           RS232 conn.  DP25P
------------------------     ---------------    ------------------------------
                                                1       PROTECTIVE GROUND

SERIAL OUTPUT          3     ------GRN------>   2       RXD
SERIAL INPUT           4   <------BLU------     3       TXD

+10V                   1     ---+---OR------->  4       CLEAR TO SEND
                                |
                                |  NC <---      5       REQUEST TO SEND
                                |  NC <---      6       DATA TERMINAL READY
                                |
GROUND                 2   <------BLK------>    7       GROUND
                                |
                                +------------>  20      DATA SET READY

ENABLE                 7   <-----YEL   NC
*******************************************************************************


*******************************************************************************
CABLE, D-CAT MODEM, 300 BAUD
DR503 conn.                     CABLE           RS232 conn.  DP25P
------------------------     ---------------    ------------------------------

..RIAL OUTPUT          3     ------GRN------>   2       TXD
SERIAL INPUT           4   <------BLU------     3       RXD

                                   NC <---      5       REQUEST TO SEND
                                   NC <---      6       DATA SET READY

GROUND                 2   <------BLK------>    7       GROUND

                                   NC <---      8       CARRIER DETECT

+10V                   1     ------OR-->NC
ENABLE                 7   <-----YEL   NC
*******************************************************************************
```

```
*****************************************************************************
CABLE, SIGNALMAN MODEM, 300 BAUD
DR503 conn.                    CABLE          RS232 conn.  DP25S
----------------------    --------------    ---------------------------

SERIAL OUTPUT        3     ------GRN------>  2       TXD
SERIAL INPUT         4    <------BLU------   3       RXD

                               NC <---       5       REQUEST TO SEND
                               NC <---       6       DATA SET READY

GROUND               2    <------BLK------>  7       GROUND

                               NC <---       8       CARRIER DETECT

+10V                 1     ------OR-->NC
ENABLE               7    <------YEL  NC
*******************************************************************************


*****************************************************************************
CABLE, IBM PC ASYNC COMM ADAPTER, 300 BAUD
DR503 conn.                    CABLE          RS232 conn.  DP25S
----------------------    --------------    ---------------------------
                                             1       PROTECTIVE GROUND

SERIAL INPUT         4    <------BLU------   2       TXD
SERIAL OUTPUT        3     ------GRN------>  3       RXD

                               NC <---       4       REQUEST TO SEND

                               NC   --->     5       CLEAR TO SEND
                               NC   --->     6       DATA SET READY

GROUND               2    <------BLK------>  7       GROUND

                               NC <---      20       DATA TERMINAL READY

+10V                 1     ------OR-> NC
ENABLE               7    <------YEL  NC
*******************************************************************************
```